THE SILURIAN TRILOBITES OF THE GIRVAN DISTRICT, STRATHCLYDE REGION, SCOTLAND

by

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"Towards evening at the Mulloch quarries among the purple heather I struck a stone on the edge and it split into slabs crowded with shells. The lime and structure of these were fresh as if dropped into the mud and sand, and solidified only a short time ago."

A.S.Alexander (1939). _Across Watersheds_.

ABSTRACT

The trilobite fauna of the Silurian successions of the Girvan area, Strathclyde Region, Scotland, is revised. Twenty eight genera (one new) belonging to the Scutelluidae, Illaenidae, Proetidae, Brachymetopidae, Aulacopleuridae, Harpetidae, Cheiruridae, Encrinuridae, Calymenidae, Phacopidae, Pterygometopidae, Lichidae and Odontopleuridae are represented, and include thirty nine named species (fifteen new), and twenty nine forms under open nomenclature. The fauna is interpreted as having occupied a shallow shelf environment. The distribution of trilobite species is compared with the shore-parallel brachiopod communities recognized in rocks of the same age in Wales and the Welsh Borderland.

CONTENTS

INTRODUCTION

The purpose of the work presented in this thesis has been to study the trilobites from the Silurian rocks of the Girvan area, to provide up to date descriptions of the species which occur, to revise their taxonomy and to establish their stratigraphical and geographical distribution.

The trilobites from the Ordovician and Silurian rocks of the Girvan area have been known for over a hundred years being first described by Salter in Murchison (1851). The major palaeontological museums of the British Isles have varied and abundant collections of Girvan material. The Girvan trilobites were first described in detail by Nicholson & Etheridge (1878-80) and Reed (1903-1935). Since then, however, the Silurian forms have been neglected until very recently when some species have been included in systematic revisions of trilobite families.

The stratigraphical nomenclature employed for the Silurian rocks of Girvan is that proposed by Cocks & Toghill (1973). The majority of the Silurian rocks are of Llandovery age with the two youngest units of either Llandovery or Wenlock age (see Page 4).

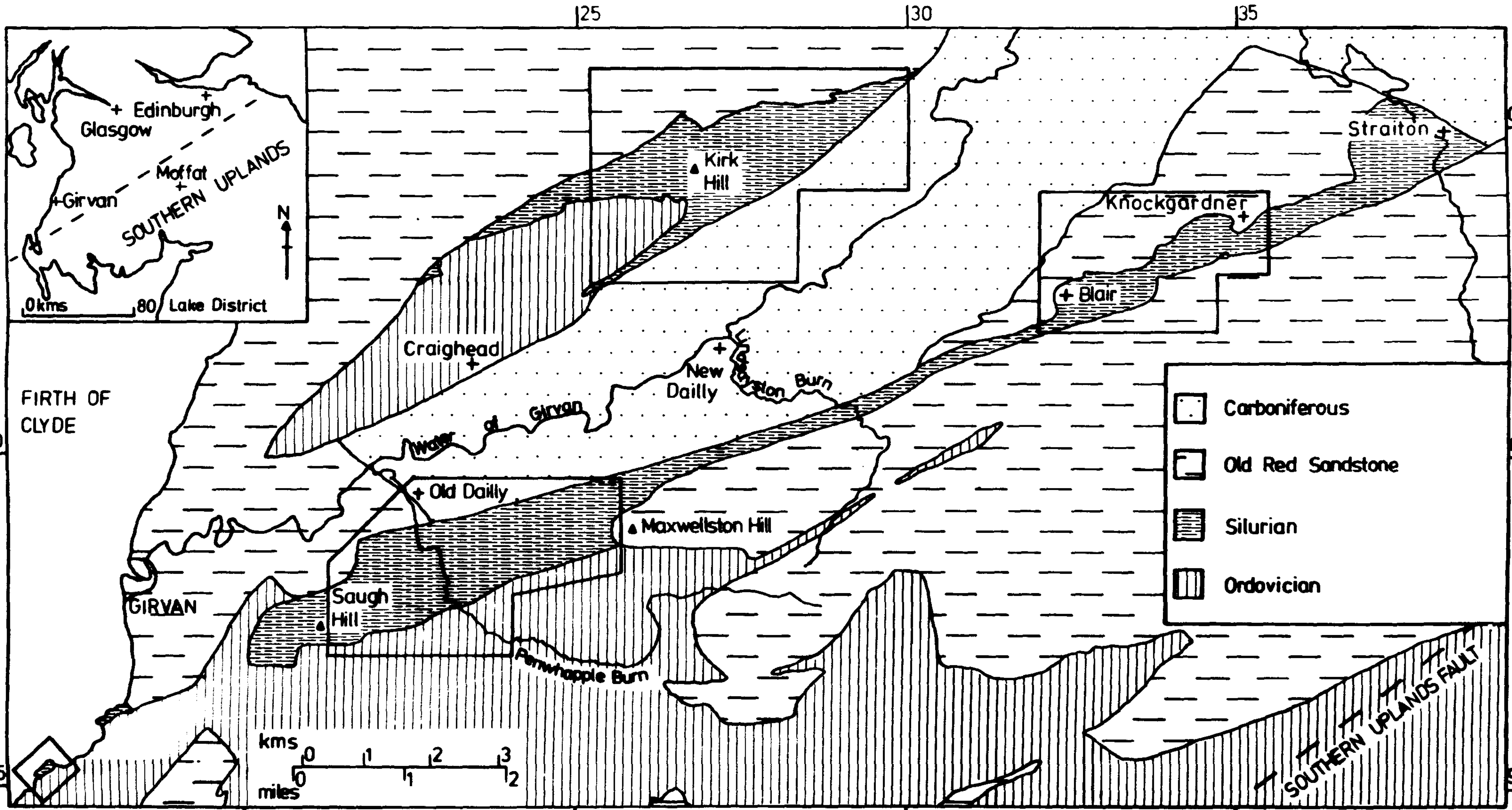
There have been very limited studies on the other fossil groups found in the Silurian rocks of Girvan eg. brachiopods (Reed, 1917), gastropods (Longstaff, 1924; Lamont, 1946), Cornulites spp (Reed, 1923), sponges, corals, trace fossils, echinoderms, conodonts (Nicholson & Etheridge, 1878-80). It is hoped that the present work on trilobites will assist in the knowledge of an otherwise poorly known Llandovery fauna.

ACKNOWLEDGEMENTS

I am deeply grateful to Dr.P.D.Lane for introducing me to trilobite studies and suggesting that the Silurian trilobites from

TEXT-FIG.1. Map showing the outline of the geology of the Girvan district.

Areas outlined are covered by enlarged diagrams. Redrawn from Cocks & Toghill (1973, text-fig.1).



25
30
35
05
00
95
20
Edinburgh
Glasgow
Moffat
Girvan
SOUTHERN UPLANDS
N
0kms
80
Lake District
Kirk Hill
Straiton
Knockgardner
Blair
Craighead
New Dailly
Lindsayston Burn
FIRTH OF CLYDE
Water of Girvan
Old Dailly
Maxwellston Hill
GIRVAN
Saugh Hill
Penwhapple Burn
kms
0
1
2
3
miles
0
1
2
SOUTHERN UPLANDS FAULT
Carboniferous
Old Red Sandstone
Silurian
Ordovician

the Girvan area might repay research. His guidance, encouragement and assistance are greatly appreciated. Professors F.W.Cope and G. Kelling are thanked for the use of departmental facilities.

I also thank Drs.D.L.Bruton, E.N.K.Clarkson, L.R.M.Cocks, J.K.Ingham, R.M.Owens, Derek Siveter, J.T.Temple, A.T.Thomas, and Mr.R.P.Tripp for useful discussion.

I have pleasure in thanking the following for kindly placing collections in their care at my disposal (abbreviated prefixes of specimen numbers given in brackets): Drs.R.A.Fortey, L.R.M.Cocks and MR.S.F.Morris, British Museum (Natural History) (BM); Dr.J.K.Ingham, Hunterian Museum, Glasgow University (HM); Dr.C.D.Waterson and Mr.W.J. Baird, Royal Scottish Museum, Edinburgh (RSM); Dr.A.W.A.Rushton, Institute of Geological Sciences, London (GSM); Drs.R.B.Rickards and D.Price, Sedgwick Museum, Cambridge (SM); Drs.I.Strachan and P.Osborne, Department of Geology, Birmingham University (BU); Mr.H.P.Powell, Oxford University Museum (OUM); Drs.R.B.Wilson and P.Brand, Institute of Geological Sciences, Edinburgh (GSE); Drs.P.Aspen and E.N.K.Clarkson, Grant Institute of Geology, Edinburgh University (GIG); Dr.D.L.Bruton, Paleontologisk Museum, Oslo.

I also thank: members of the 1975 Geologists Association field trip to Girvan and members of the Ludlow Research Group 1976 field trip to the Girvan area for collecting and donating to me many trilobite specimens; Mr.W.J.Baird for skilfully preparing specimen RSM 1967.58.46 and Mr.G.Holliday for photographing it; Dr.H.S.Torrens for assistance in locating historical references and infomation; Miss M.Cooke for scanning electron microscope work; and Dr.J.Hall, Geophysics Department, Glasgow University, for an explosion.

I am grateful to Mrs.H.Lane for translating German texts and finally to my husband for his patience, understanding and encouragement.

SPECIMEN NUMBERS

The abbreviated prefixes of specimens from museum collections are given above. Specimens from Dr.L.R.M.Cocks' own collections, as yet uncatalogued are prefixed by either LRMC or RCK. All specimen numbers prefixed 'YH' belong to the writer's own collection and the specimens will later be deposited in a museum.

STRATIGRAPHY

Early stratigraphical work was carried out on the Girvan area by Murchison 1851, Lapworth 1882, Peach & Horne 1899, and Freshney 1959. The stratigraphy of the Silurian rocks of Girvan has recently been reviewed by Cocks & Toghill 1973 and their work is strictly adhered to here. Therefore, only a summary of the stratigraphical divisions proposed by Cocks & Toghill need be given here.

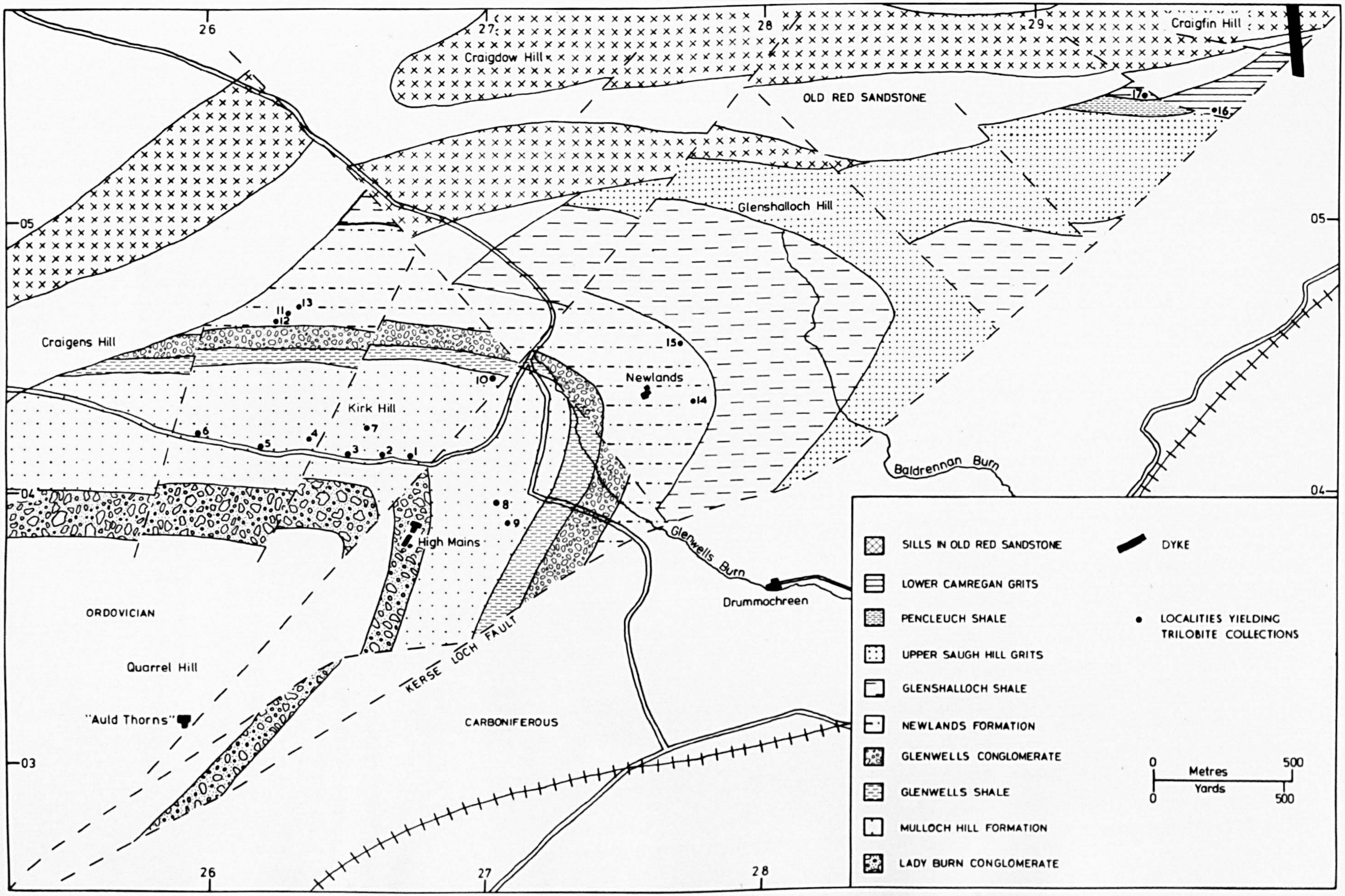
The distribution of Silurian rocks around Girvan is as in Text-fig.1. Silurian rocks occur in three main areas; the Craighead Inlier, the Coast section, and the Main Outcrop. It is possible that the whole Silurian section is of Llandovery age although the highest beds, in the extreme east, might be Wenlock.

The Craighead Inlier (Text-fig.2) is a north plunging asymmetrical anticline and its basal conglomerate lies unconformably upon two Ordovician units (the Drummuck Group and the High Mains Sandstone, both of Ashgill age). There appears to be an unbroken sequence of rocks between the acuminatus Zone (lower Rhuddanian) to the base of the sedgwickii Zone (lower Fronian) with a thin unit of uppermost sedgwickii Zone age.

The rock of the Coastal section (Text-fig.3) is unconformable upon the underlying Ordovician Shalloch Formation (low Ashgill), and also has a conglomerate at its base. The sequence here ranges from the

TEXT-FIG.2. Map showing the outcrop of the Silurian rocks of the Craighead Inlier, Girvan.

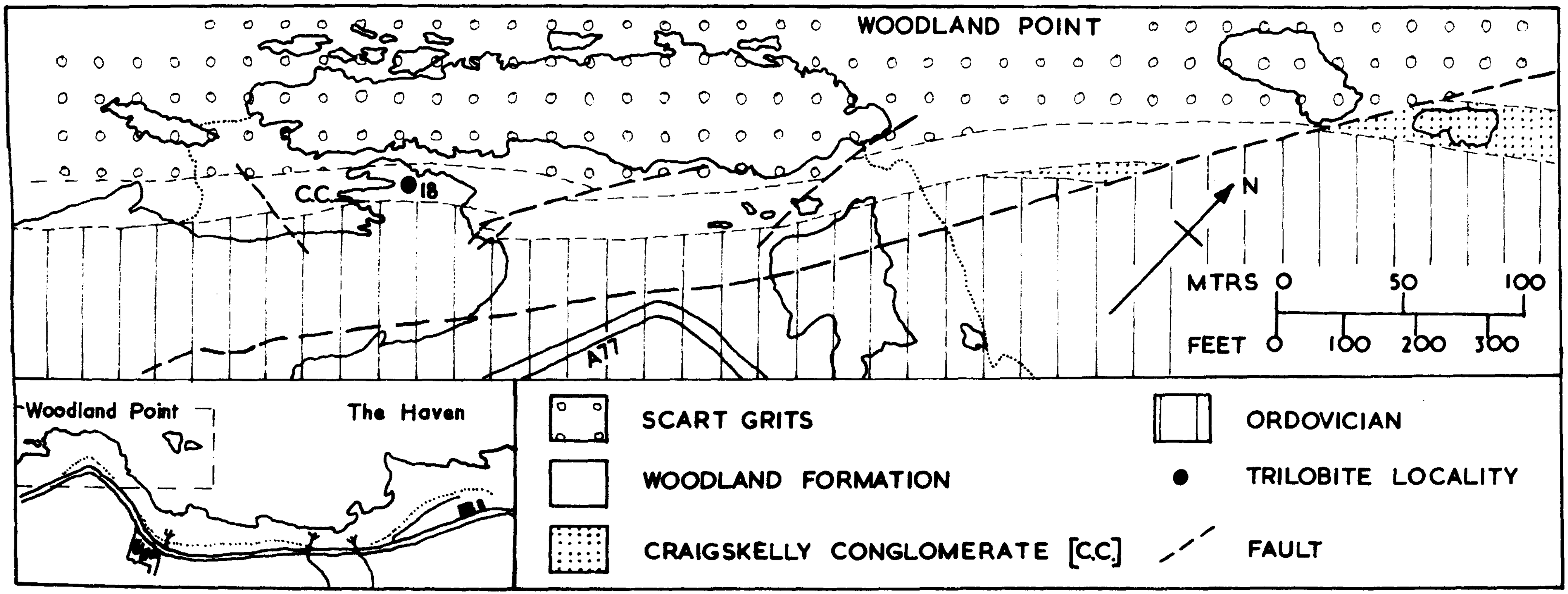
The locality numbers are those used in the text. Redrawn from Cocks & Toghill (1973, text-fig.2).



26
27
28
29
Craigfin Hill
Craigdow Hill
OLD RED SANDSTONE
Glenshalloch Hill
05
05
Craigens Hill
11
12
13
15
10
Newlands
14
Kirk Hill
6
5
4
7
3
2
1
Baldrennan Burn
04
04
8
9
High Mains
Glenwells Burn
Drummochreen
ORDOVICIAN
KERSE LOCH FAULT
Quarrel Hill
"Auld Thorns"
CARBONIFEROUS
03
26
27
28
17
16
SILLS IN OLD RED SANDSTONE
DYKE
LOWER CAMREGAN GRITS
PENCLEUCH SHALE
LOCALITIES YIELDING TRILOBITE COLLECTIONS
UPPER SAUGH HILL GRITS
GLENSHALLOCH SHALE
NEWLANDS FORMATION
GLENWELLS CONGLOMERATE
GLENWELLS SHALE
MULLOCH HILL FORMATION
LADY BURN CONGLOMERATE
0
Metres
500
Yards
0
500

TEXT-FIG.3. Map showing the outcrop of the Silurian rocks at Woodland Point.

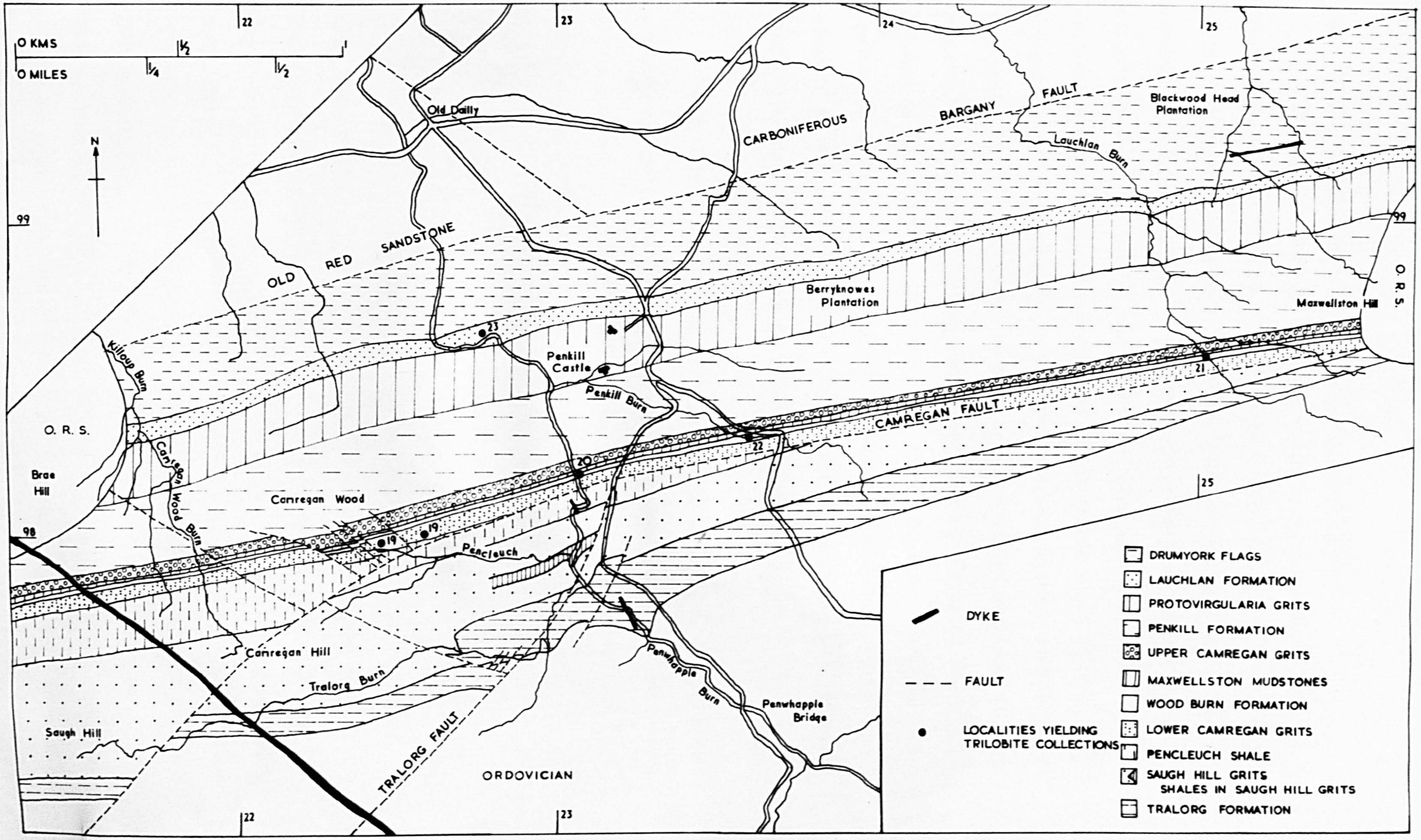
Locality 18 is "Woodland Point" of Mrs.Gray. Redrawn from Cocks & Toghill (1973, text-fig.3).


WOODLAND POINT
C.C.
18
N
A77
MTRS 0 50 100
FEET 0 100 200 300
Woodland Point
The Haven
SCART GRITS
WOODLAND FORMATION
CRAIGSKELLY CONGLOMERATE [C.C.]
ORDOVICIAN
TRILOBITE LOCALITY
FAULT

TEXT-FIG.4. Map showing the outcrop of the Silurian rocks of the Main Outcrop (Saugh Hill to Maxwellston Hill).

The locality numbers are those used in the text.

Redrawn from Cocks & Toghill (1973, text-fig.4).



0 KMS
1/2
1
0 MILES
1/4
1/2
N
22
23
24
25
99
98
Old Dailly
CARBONIFEROUS
BARGANY FAULT
Blackwood Head Plantation
Lauchlan Burn
OLD RED SANDSTONE
Berryknowes Plantation
Maxwellston Hill
O. R. S.
Killoup Burn
Penkill Castle
Penkill Burn
CAMREGAN FAULT
O. R. S.
Brae Hill
Camregan Wood Burn
Camregan Wood
Pencleuch
Camregan Hill
Tralorg Burn
Saugh Hill
TRALORG FAULT
ORDOVICIAN
Penwhapple Burn
Penwhapple Bridge
23
20
22
21
19
19
DYKE
FAULT
LOCALITIES YIELDING TRILOBITE COLLECTIONS
DRUMYORK FLAGS
LAUCHLAN FORMATION
PROTOVIRGULARIA GRITS
PENKILL FORMATION
UPPER CAMREGAN GRITS
MAXWELLSTON MUDSTONES
WOOD BURN FORMATION
LOWER CAMREGAN GRITS
PENCLEUCH SHALE
SAUGH HILL GRITS
SHALES IN SAUGH HILL GRITS
TRALORG FORMATION

base of the cyphus Zone to the lowermost gregarius Zone.

The Main Outcrop is the largest in area (Text-fig.4) stretching 30km along the NE-SW strike of the rocks on the south side of the Water of Girvan. Unfortunately, the rocks are only exposed in a few places, notably a complete sequence through the lower part of the succession at Penwhapple Glen (top of the cyphus Zone to crenulata Zone). The most eastward extent of this section (Blair-Knockgardner district, see Cocks & Toghill, 1973, text-fig.7) is the youngest and possibly extends into very early Wenlock age. There is no direct graptolite evidence that the highest two formations, Knockgardner Formation and Straiton Grits, are of Wenlock age. However, the 'red-beds' of the Straiton Grits are considered to be of Wenlock age comparable with other 'red-bed' deposits found in southern Scotland in the Carmichael Inlier (Strachan in Rolfe, 1960), the Hagshaw Hills and the North Esk Inlier of the Pentland Hills (Clarkson, Eldredge and Henry, 1977).

The whole area is composed in general of series of conglomerate, sandstones, and graptolitic shales and mudstones. The trilobites occur, with a profusion of other fossil forms, in the sandstone horizons (see Geographical Distribution Page 171).

COLLECTIONS

The prolific fossil fauna of the Girvan area has attracted many collectors over the years and the major museums in the British Isles have representatives of the fauna. The most notable collector of material from both the Ordovician and the Silurian was Mrs. Elizabeth Gray 1831-1924 (Horne, 1925, p.392) who actively collected for 70 years of her life. Most of her material was purchased by the British Museum (Natural History) in 1920 but many specimens were given to other establishments throughout Britain. Other collectors of the Girvan fauna have been:- John Smith 1845-1930 (MacGregor 1942, p.155) and

Arthur Macconochie 1850-1922 (Horne 1925, p.395) whose collections are housed in the I.G.S., Edinburgh; James Begg 1874-1958 (Nicol 1960, p. 108) whose material is housed in various museums but the majority is in the Hunterian Museum, Glasgow; E.O.Lundholm, an undergraduate from Glasgow University who mapped and collected from the Craighead Inlier and whose material is deposited in the Hunterian Museum, Glasgow.

The number of specimens of trilobites housed in museums is approximately 2,900. The author's own collections in the area which have yet to be housed in a museum have produced 1,800 specimens.

METHOD OF COLLECTION

Localities that had previously provided trilobite collections were visited by the author and comprehensive collections were made. The area was intensively searched for any new fossiliferous horizons but only a small number of new localities were found.

At most localities the rock was split up at the site but occasionally, especially at Locality 18 (Woodland Point) and the fossiliferous bands of Localities 19 (Camregan Wood) and 24 (Knockgardner Quarry), blocks were removed and later split up in the laboratory.

HISTORY OF RESEARCH

The first record of trilobites from the Silurian rocks of Girvan was made by Salter in Murchison (1851, p.171) in which he listed and figured "Illaenus sp." (pl.9, fig.3), "Phacops Stokesii" (pl.9, fig.2), "Calymene Blumenbachii" and "Encrinurus punctatus" (pl.9, fig.4). Thomson 1857, described "Acidaspis callipareos"sp nov" from the Mullock [sic] Hill sandstone of Girvan. Salter (1864-83) in his monograph of British Trilobites described the Illaenacea from the Silurian rocks of Girvan. The first attempt to elucidate the Girvan fossils was made by

Nicholson & Etheridge (1878-80) who described different fossil groups, with a large section on trilobites, based on specimens in Mrs.Gray's collections.

The only comprehensive trilobite work was produced by Reed (1903-35) in which he attempted to describe and figure all the Ordovician and Silurian species. He also relied heavily on Mrs.Gray's collections. He compared forms, often not too closely, with those from England and Wales and with those from described foreign faunas. Reed erected many species on more or less distorted material in different modes of preservation. My work indicates that many of the specific differences proposed by Reed are often due to these post depositional effects. Consequently it has become necessary to synonymise many of Reed's taxa. However, the work brought attention to the large and varied Girvan trilobite fauna.

Between 1935 and 1970 few papers were published on the Silurian trilobites of Girvan (Begg 1943, 1945, 1950, 1951; Reed 1941). Tripp (1954, 1962, 1965, 1967, 1976) has gradually revised the Ordovician trilobite fauna but the Silurian forms have been neglected.

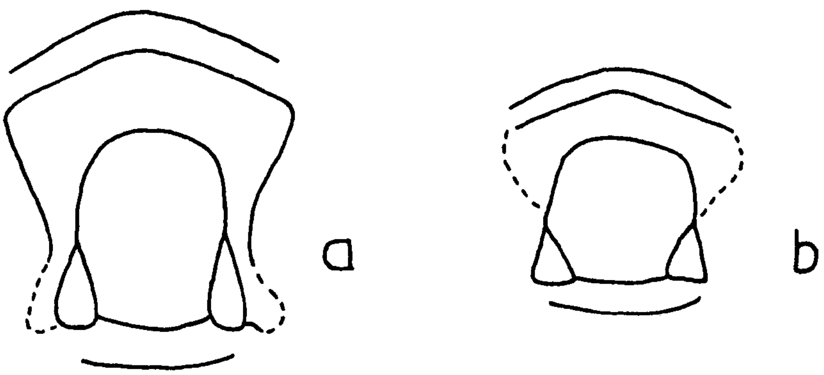
Recent work on the revised systematics of larger trilobite groups has often encompassed descriptions of some of the Silurian species, Cheiruridae by Lane 1971, Proetidae by Owens 1973, and Calymenidae by Siveter 1973.

PRESERVATION

In the majority of the Silurian localities trilobites are represented by internal and external moulds of mostly disarticulated specimens. External moulds are often lacking in museum collections and many Girvan species were known only from internal moulds.

All the Silurian rocks in the Girvan area have been subjected to tectonic and compactive distortion. This has produced trilobite specimens which show obvious angular distortion (see Pl.10, fig.12).

However, there are specimens which do not show such an obvious distortion. These have suffered distortion at right angles to, or parallel to, the sagittal line of the specimen, or have been subjected to dorso-ventral compression. This results in long and narrow forms (L-forms) and short wide forms (W-forms) (Text-fig.5) within a species (Henningsmoen 1960, p.207).



TEXT-FIG.5. Sketch diagram to show L and W forms of Harpidella newlandensis (Begg, 1950). a, L-form HM A3824. b, W-form YH N626.

TERMINOLOGY

The morphological terms used herein are essentially those of Harrington *et al.* (*in* Moore 1959 pp.0117-0126). Lateral glabellar lobes are labelled 'L' and lateral glabellar furrows are labelled 'S' and both are numbered from the posterior forwards. The following terms are used in preference to those of Harrington *et al*: 'anterior pit' is preferred to 'fossula'; 'cheek' to 'gena'; 'hypostome' to 'hypostoma'. The abbreviations 'sag.' (sagittal), 'exsag.' (exsagittal), and 'tr.' (transverse) are used to qualify such words as 'wide', 'long' etc. where such words alone might be misleading.

Additional morphological terms of taxa that have been revised subsequently to Moore 1959 are given in the description of that taxa.

Miller (1976, p.342, text-fig.2) defined differences in the structure of various raised protruberances of the trilobite cuticle previously referred to as tubercles. However, to distinguish the differing forms of protruberances (domes, true tubercles, pseudotubercles) the cuticle has to be viewed in cross-section. Where this is impossible or where no cuticle has been preserved Miller proposed that all raised structures be termed 'granules' or 'pustules' as in Moore (1959, p.O121). The term granule is preferred to pustule (but see Encrinuridae 'tubercles' Page 76).

ORIENTATION

Specimens of convex species show varying degrees of flattening and so to photograph these in any fixed orientation would be impossible. Consequently, the procedure was adopted that for any part of the exoskeleton the horizontal plane was that which maximized the visible exterior surface. Where a specimen was very convex a series of photographs of the external surface were taken (eg. Pl.7, figs.1a,b; Pl.19, figs.12a-c).

The variation in convexity of specimens and the generally distorted nature of the material has discounted the use of any biometrical methods. Where appropriate, comparative measurements have been taken following the curvature of the specimen.

LOCALITIES

Mrs.Gray collected from many localities in both the Ordovician and Silurian rocks of Girvan. In 1937 her daughter, Alice, recorded from memory on 6" Ordnance Survey maps all the localities from which Mrs.Gray made collections. These maps are housed in the British Museum (Natural History) and are available for examination. Unfortunately, Alice Gray was not always accurate in placing on a map her mother's fossiliferous sites.

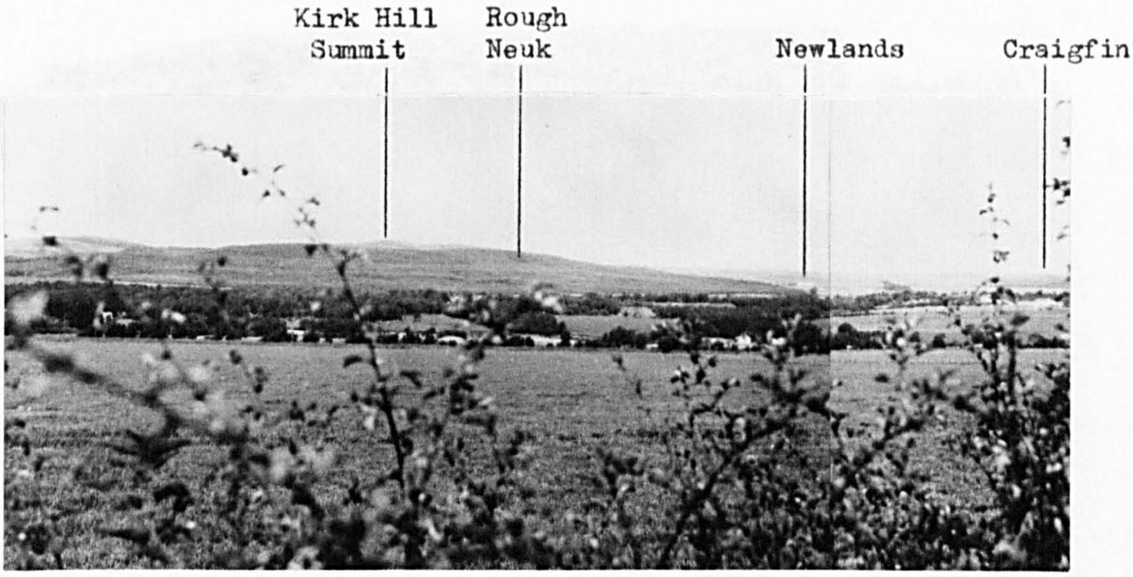
The localities from which E.O.Lundholm (an undergraduate at Glasgow University) made his collections are recorded on his 6" map of the Craighead Inlier which he presented as an undergraduate project. The map is housed in the Hunterian Museum, Glasgow.

The localities from which specimens were collected by the author and previous workers are listed below in stratigraphical order for the three main areas, with the oldest localities first. The information is presented in the following order; locality number, National Grid Reference, name given to the locality if already referred to in previous literature, location, stratigraphical horizon, the author's prefix for specimens collected at that locality by her, in parentheses..

Craighead Inlier.

(NB. Mulloch Hill used extensively throughout geological literature for the Girvan area is now termed Kirk Hill by the Ordnance Survey).

1. NS 2671 0413. Small cutting on north side of road below summit of Kirk Hill. Mulloch Hill Formation, vesiculosus Zone. (KH1).
2. NS 2659 0414. Small cutting on north side of road below summit of Kirk Hill 130m W of last locality. Horizon as locality 1. (KH2).
3. NS 2646 0415. "Mulloch Hill High Road Quarry" of Mrs.Gray termed, incorrectly, "Craigens Quarry" by Lamont 1935, and Lundholm's Locality F. Quarry on north side of road below summit of Kirk Hill 120m W of last locality. Horizon as locality 1. (KH3).
4. NS 2634 0421. Sheep scratch below Kirk Hill 150m NW of last locality. Horizon as locality 1. (KH4).
5. NS 2619 0416. Bluff on north side of road 300m W of Locality 3. Horizon as locality 1. (KH5).
6. NS 2594 0423. "Craigens" of Mrs.Gray and "Red Quarry"? of Salter (1851, p.171). Completely overgrown quarry on north side of road below Craigens Hill 250m from last locality. Horizon as locality 1.
7. NS 2654 0425. Lundholm's locality D. Sheep scratch and rabbit



TEXT-FIG.6. Craighead Inlier viewed north from the B741.

TEXT-FIG.7.

Locality 1.
NS 2671 0413

Mulloch Hill
Formation.

TEXT-FIG.8.

Locality 2.
NS 2659 0414

Mulloch Hill
Formation.

TEXT-FIG.9.

Locality 3.
NS 2646 0415

"Mulloch Hill
High Road
Quarry"

Mulloch Hill
Formation.

TEXT-FIG.10. Locality 5. NS 2619 0416
Mulloch Hill Formation.

TEXT-FIG.11.

Locality 6.
NS 2594 0423

"Craigens
Quarry"

Mulloch Hill
Formation.

excavations 120m SW of summit of Kirk Hill. Horizon as locality 1.

8. NS 2702 0399. "Mulloch Hill Quarry" and "Rough Neuk Quarry" of Mrs.Gray. Large disused quarry in Ladywell Wood 120m WSW of derelict Rough Neuk cottage. (On 21st May 1976 at 1-00pm 3lbs of explosives were used to dislodge large but loose blocks from the face of the quarry). Mulloch Hill Formation, low cyphus Zone. (R)

9. NS 2708 0390. "Mulloch Hill, in Wood" of Mrs.Gray. Outcrop in Ladywell Wood 140m SW of derelict Rough Neuk cottage, now overgrown. Horizon as locality 8.

Nicholson & Etheridge (1878, p.7) refer to "quarry at pond, SW of Rough Neuk". Lundholm gave his Locality A as NS 2685 0361 which is near to the pond in Ladywell Wood. Neither of these localities can now be found. Presumably the quarry was still active before the turn of the century when Mrs.Gray collected and Lundholm must have made his collection when the present wood was in the process of being planted. All is now overgrown.

Some specimens in Mrs.Gray's collection from her localities given above have "Mulloch Hill" only as a locality reference. This term encompasses all the localities immediately below Kirk Hill and those in Ladywell Wood. However, it is possible to differentiate between specimens from Localities 1-7 and Localities 8 and 9 because of the distinctive weathering of the rock types. The localities 1-7 are in a sandstone which has an ochreous or red weathering stain. The localities 8 and 9 are characterized by brown weathering of a 'green' sandstone. In the main body of this work, when a specimen has been given only "Mulloch Hill" as its locality, the lithology of the specimen will be denoted by the relevant locality numbers set in parentheses ie. Mulloch Hill (Localities 1-7) and Mulloch Hill (Locality 8 or 9).

10. NS 2701 0445. Lundholm's Locality H. Herein termed the "Gully". Exposure in banks of small stream which drains Kirk Hill 400m NE

of summit of Kirk Hill. Mulloch Hill Formation, cyphus Zone. (G). In the moor N of the summit of Kirk Hill specimens have been collected from exposures which have had to be dug for:-

11. NS 2626 0466. Lundholm's locality C.
12. NS 2618 0464. Freshney (1959) locality 6.
13. NS 2631 0471. Cocks & Toghill (1973).

All these localities are in the Newlands Formation, gregarius Zone.

14. NS 2775 0434. "Newlands" of Mrs.Gray. Small N-S sandstone ridge on east side of small stream 150m due east of Newlands Farm. Newlands Formation, gregarius Zone. (NW or N).
15. NS 2771 0457. Lundholm's locality G. Small exposure 200m NE of Newlands Farm. Exposure was covered over in 1975. Horizon as locality 14. (NW2).
16. NS 2964 0540. Cocks & Toghill (1973, p.217). An abandoned and overgrown pit in Craigfin Wood now inaccessible because of reafforestation. Lower Camregan Grits, sedgwickii Zone.
17. NS 2941 0545. Cocks & Toghill (1973, p.217). A pit dug in the track on the south side of Craigfin Hill now completely overgrown. Horizon as locality 16.

Coastal Section.

18. NS 1685 9520. "Woodland Point" of Mrs.Gray. Coastal section only exposed at low tide 430m W of Woodland Farm. Woodland Formation, cyphus Zone. (W).

Main Outcrop.

19. NX 2245 9799 and NX 2245 9801. "Camregan Wood of Mrs. Gray. Quarries on S side of Camregan Hill approximately 800m SW of Penkill Castle. Lower Camregan Grits, sedgwickii Zone. (C).
20. NX 2306 9819. Small exposure in E bank of Penwhapple Burn at the junction with a small tributary. Wood Burn Formation, sedgwickii Zone. (PW).
21. NX 2500 9858. "Bargany Pond Burn" of Mrs.Gray. Exposures in sides

TEXT-FIG.12.

Locality 10.
NS 2701 0445

"Gully"

Mulloch Hill
Formation.

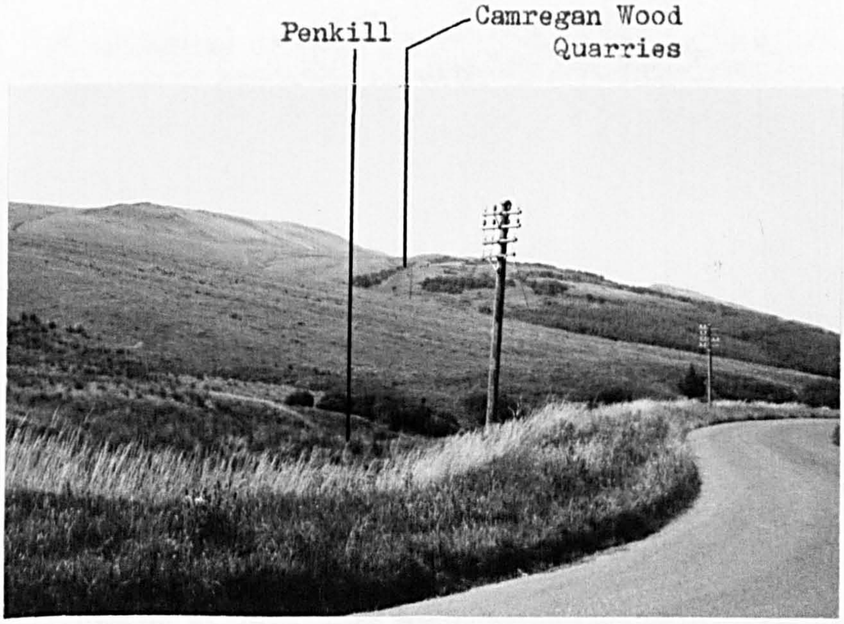
TEXT-FIG.13. Locality 18. NS 1685 9520 "Woodland Point"
Woodland Formation.

TEXT-FIG.14.

Locality 21.
NX 2500 9858

"Bargany Pond
Burn"

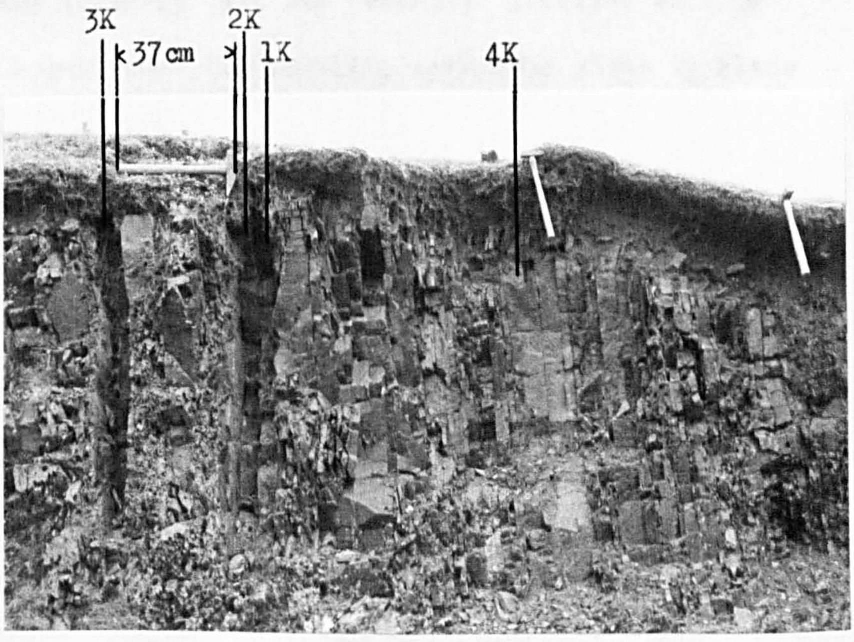
Wood Burn
Formation.



TEXT-FIG.15.

View east from NX 3267 9834 along strike of Main Outcrop.

TEXT-FIG.16. Locality 24. NS 3550 0358, Knockgardner Quarry. Knockgardner Formation.



TEXT-FIG.17.

Locality 24. NS 3550 0358

Close up of quarry face to show relative positions of beds collected.

Younging direction from right to left.

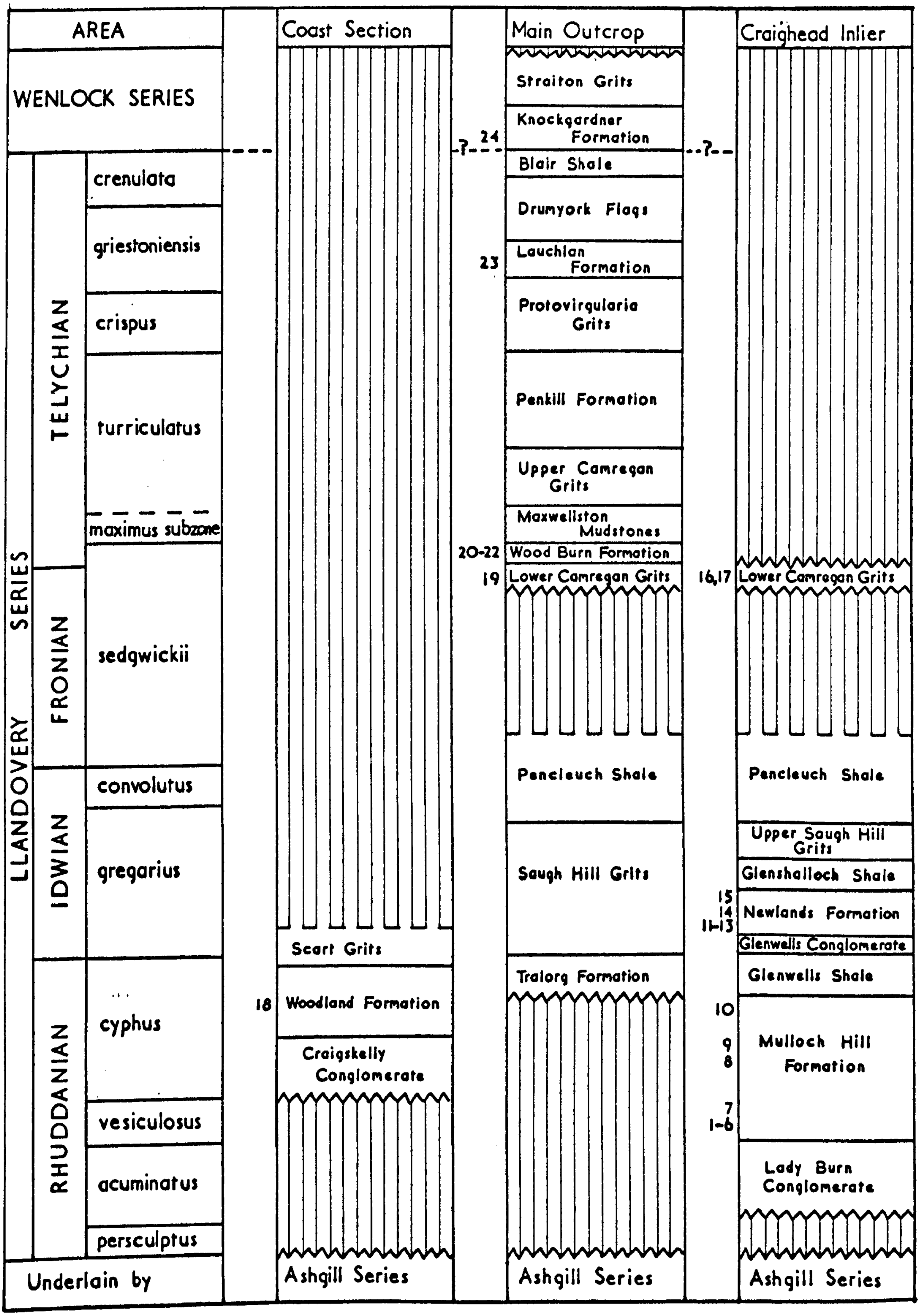
of tributary of Lauchlan Burn 1000m SW of summit of Maxwellston Hill. Horizon as locality 20. (B).

22. NX 2359 9832. "Penkill" locality of Mrs.Gray. Exposure in E bank of Penkill Burn 500m SE of Penkill Castle.
This locality was given its Grid Reference by Alice Gray on the 6" Ordnance map. An annotation by Alice Gray states that; "the rock showed on the east bank of the Penkill Burn at this spot where the burn is little more than a field drain. For many years the locality has been invisible because the grass and soil have covered over the fragment of rock that once could bee seen." The present author hoped to excavate around the area indicated by Alice Gray but in the winter of 1976-77 the owner of the land excavated the ground to lay a pipe to drain Penkill Burn. The land is now ploughed over and it is impossible to dig for solid rock. If the position of "Penkill" given by Alice Gray is correct then it should lie within the Wood Burn Formation. However, the fossil content (see section Faunal Lists) and matrix of the rock type labelled "Penkill" in Mrs.Gray's collection differ markedly from those of Bargany Pond Burn (Locality 21) and Penwhapple Burn (Locality 20) localities which lie to the east and west respectively of Penkill in the Wood Burn Formation. No other rock type in the Penkill Farm area can be compared with that from Penkill. It seems unlikely that the "Penkill" locality will be reexcavated; I accept that the locality reference given by Alice Gray is correct. Wood Burn Formation, sedgwickii Zone.

23. NX 2278 9865. "Penwhapple Glen" of Mrs.Gray. Exposure on E bank of Penwhapple Burn 350m W of Penkill Farm. The locality of "Penwhapple Glen" given by Alice Gray, NX 2293 9857, lies within the Protovirgularia Grits and the rock type of this unit is not consistent with the matrix of the specimens labelled "Penwhapple Glen" in Mrs.Gray's collections. However, the rock type of the Lauchlan Formation is similar to that of "Penwhapple Glen" specimens although it is not a

TEXT-FIG.18. Stratigraphical successions for the three main areas of outcrop of Silurian rocks in the Girvan district.

Vertical shading indicates breaks in succession. Locality numbers used in the text are given beside the columns. Modified from Cocks & Toghill (1973, text-fig.9).


AREA
WENLOCK SERIES
LLANDOVERY SERIES
TELYCHIAN
FRONIAN
IDWIAN
RHUDDANIAN
crenulata
griestoniensis
crispus
turriculatus
maximus subzone
sedgwickii
convolutus
gregarius
cyphus
vesiculosus
acuminatus
persculptus
Underlain by
Coast Section
Scart Grits
18
Woodland Formation
Craigskelly Conglomerate
Ashgill Series
Main Outcrop
Straiton Grits
Knockgardner Formation
?
24
Blair Shale
Drumyork Flags
23
Lauchlan Formation
Protovirgularia Grits
Penkill Formation
Upper Camregan Grits
Maxwellston Mudstones
20-22
Wood Burn Formation
19
Lower Camregan Grits
Pencleuch Shale
Saugh Hill Grits
Tralorg Formation
Ashgill Series
Craighead Inlier
?
16,17
Lower Camregan Grits
Pencleuch Shale
Upper Saugh Hill Grits
Glenshalloch Shale
15
14
11-13
Newlands Formation
Glenwells Conglomerate
Glenwells Shale
10
9
8
7
1-6
Mulloch Hill Formation
Lady Burn Conglomerate
Ashgill Series

particularly shelly horizon. It is presumed that Alice Gray made a mistake and the "Penwhapple Glen" locality can be transferred NW to a similar bend in the burn which lies within the Lauchlan Formation. Lauchlan Formation, crispus Zone.

24. NS 3550 0358. Knockgardner Quarry in field S of road 400m NE of Knockgardner Farm. There is no direct graptolitic evidence to indicate whether this formation belongs to the very late Llandovery or early Wenlock. Cocks & Toghill (1973, p.233) prefer to place the formation in the Wenlock Series because the brachiopod fauna is not analogous with any in the Llandovery. The formation is here doubtfully placed in the Wenlock Series until better evidence for its age is obtained. Knockgardner Formation,?Early Wenlock. (K).

SYSTEMATIC DESCRIPTIONS

Superfamily ILLAENACEA Hawle & Corda, 1847.

Discussion. The many past classifications of this superfamily have varied widely in the delimitation of families and subfamilies (see Prantl & Přibyl (1946), Jaanusson (1954), R. & E. Richter (1955), Šnajdr (1960), Erben (1967), Maksimova (1968), Přibyl & Vaněk (1971), Pillet (1972), Kobayashi & Hamada (1974)). This indicates the particular difficulty of inferring relationships amongst these variously effaced forms. Many subfamilies have been erected which purport to indicate relationships between genera. Often however, such subfamilies constitute genera which are similar in dorsal morphology since they have reached a similar stage of effacement. No account has been taken of the progressive effacement in phylogeny. The full significance of homoeomorphy has not been considered in any classification so far proposed.

It has been suggested that a limited number of early groups produced effaced later forms. But the occurrence of distantly related effaced forms in the group at widely differing times from the Arenig (eg. Dysplanus Burmeister, 1843) to the Devonian (eg. Paralejurus Hawle & Corda, 1847) indicates effacement to be a process operating on this group (as on many others) at different times.

All members of the Illaenacea are here referred to one of two families, the Scutelluidae Richter & Richter, 1955 and

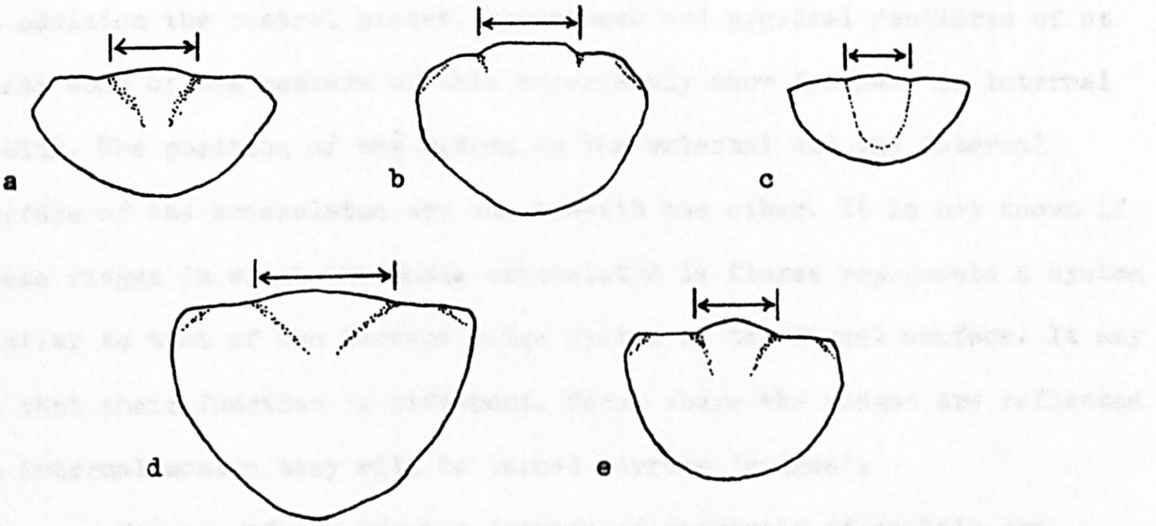
Illaenidae Hawle & Corda, 1847. The present author agrees with Whittington (1963, p.83) who merged the Styginidae Skjeseth, 1955 with the Scutelluidae. Further, the members of the subfamilies Goldillaeninae Balashova, 1959 and Bumastinae Raymond, 1916 are also included in the Scutelluidae. The subfamily Panderinae Bruton, 1968a is rejected as it is considered too premature to elevate the Panderia Volborth, 1863 and Ottenbyaspis Bruton, 1968a genus group of effaced forms to the rank of subfamily. The relatively small size of all the species of this group, not more than 5.0mm in transverse width across the palpebral lobes, leads the present author to query if these small forms could represent immature stages of other 'larger' genera within the Illaenidae. Ectillaeninae Jaanusson, 1959 and Illaeninae Hawle & Corda, 1847 are also rejected because forms referred to them are known for the most part by their dorsal morphology only but may be conveniently regarded as morphological 'species-groups'. Knowledge of the dorsal surface only can be misleading because of effacement. Internal surfaces of species so far described are very distinctive since they are less subject to effacement. Detailed studies of ventral morphology will produce a 'natural' classification. The very many Scutelluidae subfamilies often based on poorly known forms, eg. Meroperixinae Kobayashi & Hamada, 1974 and Octobronteinae Maksimova, 1968 are also rejected since evidence is at present lacking which would indicate that their contained members are phylogenetically related.

Many species of this superfamily which are highly effaced show radiating structures on their pygidia. These structures radiate from an area which is here considered analogous to the pygidial axis in the Scutelluidae (sensu Šnajdr, 1960). These structures vary in form; in Rhax polinctrix Lane & Thomas, 1978 in press, they are represented by indistinct ridges and interruption of the surface sculpture; in Stenopareia acymata sp. nov., S. catathema sp. nov. and S. aemula (Salter, 1867) they are low ridges which are often flat topped; in Cybantyx anaglyptos Lane & Thomas, 1978a in press, they are dark patches; and in the "indeterminate illaenid" Perry & Chatterton, 1977 they are represented by "crimpings" on the border of small specimens, These structures are assumed to be indications of relic pleurae.

The terminology used in describing the Illaenacea is essentially that of Jaanusson (1954) and Šnajdr (1960) which they employed for the Illaenidae and Scutelluidae respectively. Jaanusson (1954, p.552) however, used two terms (lateral impression and lateral pit of the cranidium) to describe the sunken depressed feature adjacent to the axial furrow; the present author agrees with and employs Šnajdr's 'lateral muscle impression' for this feature. In the Illaenidae the lateral muscle impression is considered a feature of the fixed cheek by homology with this feature in members of the Scutelluidae (sensu Šnajdr, 1960). It is considered that its function is similar throughout the superfamily because of its persistency and constant position. However, until a better knowledge of the functional morphology of members of the Illaenacea is acquired through ontogeny, histology, phylogeny etc., the purpose of the lateral impression is in doubt.

The granule sometimes found anterior to the anterior pit (Jaanusson 1954, p.548) of the cranidium will here be termed the anterior granule of the cranidium. This granule when present is usually seen most clearly on an internal mould but it is not always visible on the external surface of the same specimen. Its function is unknown but its constant close proximity to the anterior pit would suggest that it played some part in hypostomal attachment.

The forward projection of the anterior margin of pygidia of members of the Illaenidae (sensu Jaanusson, 1954) has often been taken to represent the true lateral extent of the pygidial axis. However, as more pygidia are examined and the position of muscle impressions plotted it seems likely that the 'true' pygidial axis lies within a relatively narrow (tr.) and short (sag.) median area. This area corresponds to the position of the well defined pygidial axis of members of the Scutelluidae



TEXT-FIG.19. Sketch diagrams to show the relative position of the median arch (between vertical lines) in various genera of Illaenacea. a, Illaenus; b, Stenopareia; c, Panderia; d, Platillaenus; e, Dysplanus. (Outlines taken from Moore, 1959)

(sensu Šnajdr, 1960). To avoid confusion regarding the position of the 'true' axis and the whole anterior projection the author has employed the term 'median arch' as proposed by Begg (1945, p.110) for the latter. The median arch is delimited laterally by a distinct change of slope (see Text-fig.19). The median arch is not necessarily homologous throughout the group and it is possible for the lateral extents of the true axis and the median arch to be coincident.

The majority of members of the Scutelluidae possess a sagittal ridge (median groove of Whittard 1940, p.294; postaxial ridge of Whittington 1965, p.402) which extends from approximately middle length of the pygidium to the posterior border. Occasionally the ridge may be grooved. This feature is here termed the pygidial sagittal ridge.

The dorsal surfaces of many members of the Illaenacea carry terrace ridges (Miller, 1975) often in association with punctae. Occasionally these terrace ridges are reflected on the internal surface eg. Bojoscutellum paliferum paliferum (Beyrich, 1845) (Šnajdr 1960, pl.10, fig.7) and Kosovopeltis svobadai Šnajdr 1958 (Šnajdr 1960, pl.3, fig.15). In addition the rostral plates, hypostomes and pygidial doublures of at least some of the members of this superfamily show 'ridges' on internal moulds. The position of the ridges on the external and the internal surface of the exoskeleton are one beneath the other. It is not known if these ridges in which the whole exoskeleton is flexed represents a system similar to that of the terrace ridge system of the dorsal surface. It may be that their function is different. Here, where the ridges are reflected on internal moulds they will be termed terrace 'ridges'.

Because of the varying degrees of convexity of cephala and pygidia of this superfamily and the secondary feature of distortion and flattening, it has been necessary to measure length (sag.) and width (tr.) around the circumference.

Family SCUTELLUIDAE Richter & Richter, 1955

Diagnosis. See Lane & Thomas, 1978a in press, who also discuss the composition and delimitation of the family.

Genus Bumastus Murchison, 1839

Type species. By monotypy; Bumastus Barriensis Murchison 1839, p.656, pl.7bis, figs.3a-c, pl.14, figs.7a,b; from the Barr Limestone Member, Coalbrookdale Formation (Wenlock Series), Hay Head lime works, Great Barr, Walsall, West Midlands.

Diagnosis. See Lane & Thomas, 1978a in press.

Bumastus? vulsus sp. nov. Pl.3, figs.15-17, Pl.4, figs.1-10.

Name. Latin 'vulsus', meaning having the hairs plucked out; pertaining to the 'smoothness' of the dorsal shield.

v.1879 Illaenus nexilis, Salter (?); Nicholson & Etheridge, p.159 (pars), pl.11, fig.13.

1899 Illaenus (Bumastus) barriensis (Murch); Peach & Horne, p.538 [List] v*1904 Illaenus barriensis (Murchison), pars 1839; Reed, p.58, pl.9, figs.1,2.

Holotype. BM In21755, Pl.4, fig.2, partly exfoliated pygidium, figured Reed 1904, pl.9, fig.2; from Wood Burn Formation, Locality 21 (Bargany Pond Burn).

Material, localities and horizons. Numerous specimens belonging to this species are available in the major British palaeontological collections and no attempt is made to give a comprehensive list. Details of material figured herein are as follows. From type locality: BM In21754 (Pl.4,fig.1), figured Reed 1904, pl.9, fig.1, GSE M2676[b] (Pl.3, fig.16), GSE M2682[a] (Pl.4, fig.3), cranidia; BM In21719 (Pl.4, fig.5), BM In21760 (Pl.4, fig.8), free cheeks; GSE M2587[a] (Pl.3, fig.17), GSE M3008[d] (Pl.4, fig.7), YH B154a (Pl.4, fig.10), YH B153b (Pl.4, fig.6), pygidia. From Wood Burn Formation, Locality 22: BM In21759 (Pl.3, figs.15a,b) dorsal shield; BM In21710 (Pl.4, figs.4a,b), figured Nicholson & Etheridge 1879, pl.11, fig.13, rostral plate; GSM 4261 (Pl.4, fig.9), pygidium. This species is also found at ?Lauchlan Formation, Locality 23.

Diagnosis. Exoskeleton gently convex. Axial furrow shallow posteriorly, dying out before anterior limit of palpebral lobe. Anterior pit present on internal moulds at least. Median granule small and far back on glabella. Anterior section of facial suture reducing cranidium to 2/3 maximum (tr.) width just anterior to palpebral lobe. Eye ¼ length of cranidium, with adjacent deep and wide furrow on free cheek. Pygidial external surface with terrace ridges subtransversely aligned; anteromedially 3 pairs and one central muscle impression on internal mould. Doublure ¼ length (sag.) of pygidium in dorsal view, anterior edge of doublure concentric with posterior margin.

Dimensions of holotype. Sagittal length, 18.5mm; maximum width, 26.5mm.

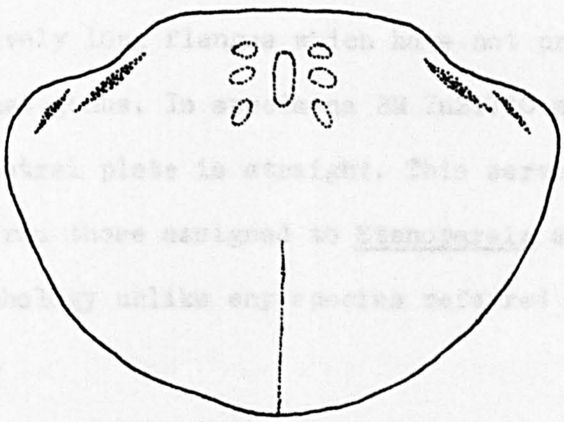
Description. Cranidium not greatly convex, slightly wider (tr.) across palpebral lobes than long (sag.). Glabella with no visible muscle impressions, narrowest opposite palpebral lobes where $\frac{1}{5}$ width of cranidium, expanding posteriorly. Posterior section of axial furrow shallow, directed backwards and outwards behind palpebral lobe terminating at apodemal pit. Anterior section of axial furrow very shallow and ill-defined dying out opposite anterior limit of palpebral lobe. Lateral muscle impression deep, suboval in outline, positioned opposite palpebral lobe astride axial furrow. Anterior pit of cranidium positioned $\frac{1}{4}$ length (exsag.) of cranidium from anterior margin. Median granule positioned far back on the glabella. Palpebral lobe semicircular in outline, approximately $\frac{1}{4}$ cranidial length (sag.), anteriorly reducing cranidium to 2/3 maximum width (tr.). Anterior section of facial suture curving abaxially to lateral extent less than that of palpebral lobe, curving adaxially before cutting anterior margin. Posterior section of facial suture cutting posterior border at acute angle. Sculpture, only known anteriorly as terrace ridges parallel to anterior margin. Free cheek subtriangular in outline, $1\frac{1}{2}$ times wider (tr.) than long (exsag.), gently convex, with deep wide furrow around base of visual surface. Visual surface tapering alittle posteriorly. Surface with faint terrace ridges lying subparallel with lateral margin describing vortex at genal angle.

Rostral plate approximately $2\frac{1}{2}$ times wider than long. Anterior margin straight. Connective sutures obliquely aligned at approximately 20° to exsagittal. 9 terrace 'ridges' not greatly raised, parallel with transverse margins, Posterior flange bent dorsally parallel with ventral surface, at least $\frac{1}{4}$ length (sag.) of plate.

Thorax, number of segments unknown, with central axial region 2/5 total width (tr.), axial furrow deep with strongly raised ridge lying parallel and abaxially. Segments without sculpture.

Pygidium 1 1/3 times wider (tr.) than long (sag.). Median bow just over $\frac{1}{2}$ width of pygidium projecting some distance anteriorly infront of articulating facet. Articulating facet about 3/8 width of median bow at angle of 50° from transverse. External surface with fine terrace ridges subtransversely aligned, tending to converge at posterior limit of articulating facet. Internal mould with narrow anterior border widening alittle laterally; pygidial sagittal ridge visible for posterior $\frac{1}{2}$ of pygidium. Muscle impressions just discernable on a few internal moulds, consisting of 3 pairs of oval shaped impressions, posterior impressions larger than anterior, positioned closer together posteriorly and with central impression between first 2 anterior pairs. Pygidial doublure $\frac{1}{4}$ length (sag.) of pygidium, anterior edge of doublure concentric with posterior margin, terrace ridges subparallel with posterior border.

Discussion. This species is an effaced scutelluid which lacks cephalic axial furrows anteriorly. The effacement makes it difficult to assign the species to any known genus. It is referred to Bumastus? as it most closely resembles members of this genus. However, the type of Bumastus, B. barriensis Murchison, 1839 has no anterior pit and is much more convex than the Girvan species. Unfortunately, the cranidium of B? vulsus is not well enough preserved to show the axial muscle impressions. Lane & Thomas, 1978a in press, use muscle impressions as one of the features by which they delimit genera. However, the pygidial muscle impressions can be seen on specimens GSE M3008[d] (Pl.4, fig.7) and YH B154a (Pl.4, fig.10), see Text-fig.20. They differ from those of Bumastus (s.s.)



TEXT-FIG.20. Bumastus? vulsus sp. nov. Diagrammatic representation of the internal surface of pygidium showing the arrangement of pygidial muscle impressions. Magnification approximately x3.

in that the anteromedian muscle impression is elongate sagittally and the 3 pairs of muscle impressions are small and do not extend far beyond the posterior limit of the anteromedian impression. B? vulsus is excluded from the Illaenidae because of its large eyes and non-modification of the anterior margin of the pygidial doublure.

Two specimens (BM In21710, Pl.4, figs.4a,b; BM In21715) are tentatively identified as rostral plates, and assigned to this species. Another similar form of rostral plate is also found at Locality 22 but the relatively larger size of the latter indicates its association with the larger form of Stenopareia catathema sp. nov. common at this locality. The plates assigned to B? vulsus differ from all other Illaenidae and Scutelluidae rostral plates previously described in possessing a straight anterior margin and a long (sag.) dorsal flange parallel to the ventral surface. Dorsal flanges have been described in various illaenids and scutelluids, eg. Illaenus marginalis Raymond, 1925 (Whittington 1965, pl.47, fig.10) has an axe-shaped rostral flange; Stenopareia linnarsoni (Holm, 1882) (Jaanusson 1954, fig.8B) and B. barriensis Murchison, 1839 (Lane & Thomas, 1978a in press) have wider (tr.) but shorter (sag.) rostral flanges. In B? vulsus the flange is apparently almost as wide (tr.) as the maximum width of the rostral plate and in addition is longer than previously described flanges. Rostral plates below assigned to Stenopareia also possess wide and relatively long flanges which have not previously been described in species of that genus. In specimens BM In21710 and In21715 the anterior margin of the rostral plate is straight. This serves to distinguish those rostral plates from those assigned to Stenopareia and additionally make their gross morphology unlike any species referred to Bumastus.

Genus Kosovopeltis Šnajdr, 1958

[=Eokosovopeltis Přibyl & Vaněk, 1971; Heptabronteus Webby, 1974 (see P.170)]

Type species. Original designation; Kosovopeltis svobodai

Šnajdr 1958, p.178, pl.2, figs.8-13; from the Kopanina Formation (Ludlow) of Kosov, near Králův Dvůr, Czechoslovakia.

Other species. To those given by Šnajdr, 1960 should be added; K. nebula and K. hypha both Campbell, 1967; K. yichangensis Mu et al., 1974; K. angusticosta Kobayashi & Hamada, 1974; K. romanovskii (Weber, 1948); K. norilskensis (Maksimova, 1962); "Scutellum estonicum" (sensu Öpik 1937, pl.5, fig.2, non pl.9, fig.4, non Schmidt 1894); K. borealis (Poulsen, 1934)

Diagnosis. As that given by Šnajdr (1960, p.247) with the amendments outlined by Campbell (1967, p.12) that the median unpaired rib of the pygidium can be bifurcate and the width of the pygidial doublure can vary considerably about the half length of the postaxial area.

Discussion. Of the time ranges known for the genera of the 'Scutellum' group only Eobronteus Reed, 1928a is known definitely to occur in the Llandovery. In addition Octobronteus Weber, 1945 and Eokosovopeltis Přibyl & Vaněk, 1971 may have representatives in the Llandovery. "Bronteus andersoni" Etheridge & Nicholson, 1879 and "Scutellum cunctatum" Reed, 1931 from Girvan differ from Eobronteus and Octobronteus in not possessing a long preglabellar field and by having seven pairs of pygidial ribs. Eokosovopeltis is known from the Caradoc of Estonia and possibly from the Llandovery of the Siberian Platform. This genus embraces species eg. E. romanovskii Weber, 1948 which are very similar to "Scutellum cunctatum". Eokosovopeltis is poorly known and its diagnosis having many features characteristic of the Scutelluidae as a whole. Its most diagnostic features are the lack of a long (sag.) anterior border and isolate glabellar muscle impressions positioned close to the axial furrows. With those attributes there is no reason to separate it from Kosovopeltis. Hence, Kosovopeltis now has a time range from the Caradoc through to the Ludlow*. Šnajdr (1960, p.240, text-fig.15) considered that all members of the Scutelluidae (sensu Šnajdr, 1960) evolved from a Caradocian Eobronteus stock. Also he proposed that Kosovopeltis had arisen from a form close to the Wenlock Planiscutellum Richter & Richter, 1956. However, now that the

*see P.171

time range for *Kosovopeltis* has been extended back to the Caradoc it is clear that at least *Bobronteus* and *Kosovopeltis* 'groups' were evolving side by side in the Caradoc.

1. *Kosovopeltis cunctatum* (Reed, 1931   Pl.1, figs.1-13.

1899 *Bronteus Andersoni* (Nich. & Eth.); Peach & Horne, p.532 /List/

1899 *Bronteus Andersoni* (Eth. & Nich.); *Ibid*., p.542 /List/

v*1931 *Scutellum* (*Bronteus*) *cunctatum* Reed, p.97, pl.4, figs.1-4.

1931a *Scutellum* (=*Bronteus*) *cunctatum* Reed; Reed, p.25.

Lectotype. Selected herein; HM A1062, Pl.1, fig.7, internal mould of cranidium; figured Reed 1931, pl.4, fig.2; from Newlands Formation, Locality 14 (Newlands Farm).

Paralectotypes. From type locality: HM A1061 (Pl.1, fig.4), figured Reed 1931, pl.4, fig.1, cranidium; HM A1063 (Pl.1, fig.10), figured Reed 1931, pl.4, fig.3, HM A1064 (Pl.1, fig.13), figured Reed 1931, pl.4, fig.4, pygidia.

Material, localities and horizons. This species is well represented in all the major palaeontological collections in the British Isles and no attempt is made to give a comprehensive list. Details of material figured herein are as follows. From type locality: YH NW422 (Pl.1, fig.1), BM It9109 (Pl.1, fig.5), YH NW420 (Pl.1, fig.8), cranidia; HM A5717 (Pl.1, fig.3) free cheek; YH NW450 (Pl.1, figs.9a-c) hypostome; HM A5828 (Pl.1, fig.11), BM In22659 (Pl.1, figs.12a,b), pygidia. From Newlands Formation, field section midway between Locality 8 and Locality 14: HM A1142 (Pl.1, fig.2) cranidium. From Newlands Formation, Locality 11: HM A1140 (Pl.1, figs.6a,b) free cheek. Also specimens have been collected from Woodland Formation, Locality 18; Mulloch Hill Formation, Locality 10.

Diagnosis. Cephalon gently inflated. 1g, 2g and 3g glabellar muscle impressions separate and close to axial furrow. Glabella virtually parallel-sided posteriorly. Axial furrows dying out just anterior to 3g.

Anterior border absent medially. Fixed cheek narrow (tr.). Eye small. Hypostome only gently inflated. Pygidium with 7 pairs of ribs and non-bifurcate median rib.

Dimensions of lectotype. Cranidial sagittal length, 8.0mm; cranidial maximum width, 7.75mm.

Description. No complete specimen known. Cranidium 1¼ times wider (tr.) between anterolateral margins than long (sag.). Frontomedian glabellar lobe 1/3 width (tr.) of cranidium at posterior, from occipital furrow narrows very slightly anteriorly then widens markedly forward to twice posterior width, sloping down to anterior margin. Occipital ring twice as wide (tr.) as long (sag.), 4 times wider than long laterally; curved in outline posteriorly. Occipital furrow wide and shallow, transverse for median 1/3 of glabella width, deeper behind occipital muscle impression. Occipital muscle impression 1 1/3 wider (tr.) than long (exsag.). 1g 1 1/3 times longer (exsag.) than wide (tr.), kidney shaped in outline with indentation facing axial furrow, as long (exsag.) as occipital ring (sag.), close to axial furrow which here is flexed convex outwards. 2g exsagittally anterior to 1g, ½ length (exsag.) of, and that distance infront of, 1g; subcircular. 3g same size and shape and same distance from axial furrow as 2g. Axial furrow to opposite 2g deeper than occipital furrow, dying out just anterior to 3g. Very narrow anterior border and depression present laterally but absent infront of middle ½ of glabellar lobe. Fixed cheek longer (exsag.) than wide (tr.); lateral muscle impression oval in outline. Palpebral lobe semicircular in outline, equal in length (exsag.) to, and opposite lateral muscle impression. Posterior border furrow distinct only behind palpebral lobe. Posterior border short (exsag.). Furrows, lateral muscle impression of free cheek and glabellar impressions without sculpture. All other dorsal surfaces of cranidium with terrace 'ridges' subparallel to axial furrow on posterior part of free cheek. Free cheek elongate, rounded anteriorly, produced into short spine posteriorly. Area around eye flat, wide depression abaxially for full length of free cheek but lateral edge of free cheek at same height as area around eye. Visual surface 1/5 length (exsag.) of free cheek, crescentie in outline, bearing 30-40 files of lenses more than 16 lenses high. Terrace 'ridges' transverse posterior to eye, curving anteriorly on level with and anterior to, visual surface. Doublure extending to flat area around eye, almost flat posteriorly, convexity increasing considerably anteriorly, with about 10 terrace 'ridges' subparallel to lateral margin of free cheek but transversely directed behind eye.

Rostral plate unknown.

Hypostome subtrapezoid in outline, approximately as wide (tr.) across anterior wings as long (sag.). Middle body narrowing slightly and decreasing in convexity posteriorly. Anterior lobe convex, steep-sided laterally, 2/3 length of middle body. Macula ellipical in outline, obliquely aligned, convex. Posterior lobe of middle body much less convex than anterior lobe. Anterior margin smooth curve in outline, no anterior border. Anterior wing triangular in outline, slightly turned down. Lateral border narrow, widening alittle opposite macula, merging into posterior border. Posterior border ⅛ length (sag.) of whole. Lateral border furrow wide and deep just posterior to anterior wings and opposite posterior part of anterior lobe. Middle furrow deep, but narrower than lateral furrow, running immediately anterior to macula. Lateral border furrow shallow and wider posteriorly, merging with indistinctly defined posterior border furrow. Whole surface with distinct terrace 'ridges' lying subparallel to outline of posterior border. Macula without sculpture.

No thoracic segments known.

Pygidium approximately 1 1/3 times wider (tr.) than long (sag.) in large specimens (1⅛ times wider than long in smaller specimens), semi-elliptical in outline. Pygidial axis sutriangular in outline, 1/5 maximum width (tr.) and 1/5 length (sag.) of pygidium, steep-sided and flat topped. Axial rings possibly indicated by weak transverse furrows (Pl.1, figs.10, 12a). Axis posteriorly weakly trilobate. Pleural field slightly concave near posterolateral margin, with 7 radiating ribs which expand abaxially to about 3 times their width adjacent to axial furrow, simple median rib wider (tr.) than others. Terrace 'ridges' on axis transverse, on pleural field subparallel to posterolateral margin but slightly projected anteriorly on median rib. Doublure extending anteriorly to ½ length of pygidium, with terrace 'ridges' subparallel to posterior margin.

Discussion. Reed (1931, pl.4, fig.4) figured specimen HM A1064 (Pl.1, fig.13) as Scutellum (Bronteus) cunctatum. He stated that this specimen was malformed with only 6 pleurae on the right hand side, but with 7 on the left. It is a poorly preserved specimen. However, the specimen is not malformed but the furrow between the median rib and the seventh rib on the right hand side is very shallow and indistinct but is clearly seen adaxially.

K. cunctatum most closely resembles K. nebula Campbell (1967, p.12, pl.2, figs.1-8, pl.3, figs.1,2,4; text-fig.1), from the Henryhouse Formation (Upper Wenlock-Lower Ludlow), Oklahoma, U.S.A. However, they differ in that the latter has a transverse, short (exsag.) 3g muscle impression which is not so well defined.

The cranidium of cunctatum resembles that from the Lower Silurian of Estonia figured by Öpik (1937, pl.5, fig.2) as Scutellum estonicum (Schmidt, 1894). It is doubtful if this cranidium is conspecific with that figured by Schmidt (1894, pl.3, fig.1) from the Eastern Baltic region of Russia. The specimen figured by Schmidt has an occipital ring of equal length for all its width and an anterior border. The cranidium from Estonia has no anterior border and the occipital ring is narrower laterally than medially. In this respect the Estonia form is similar to cunctatum. However the Estonia form differs from that of Girvan in that the axial furrows of the cranidium extend further forwards and the lateral muscle impressions are positioned further from the axial furrows.

K. cunctatum differs from all other members of the genus by possessing cranidial axial furrows which become very indistinct ¾ way forwards, no anterior border medially and an almost flat pygidium.

2. Kosovopeltis andersoni (Etheridge & Nicholson, 1879) Pl.1, figs.14-17, Pl.2, figs.1-7.

v*1879 Bronteus Andersoni, Etheridge jun., and Nicholson (sp. nov.); Nicholson & Etheridge, p.162, pl.12, figs.3-5.

1899 Bronteus Andersoni (Eth & Nich); Peach & Horne, p.536 [List]

1899 Bronteus Andersoni (N & E); Ibid., p.538 [List]

v.1904 Bronteus andersoni Nicholson and Etheridge, 1879; Reed, p.87, pl.12, figs.8-11.

1928a Bronteus andersoni Nich & Eth; Reed, p.52,61,67.

1931a Scutellum (=Bronteus) andersoni (Nicholson and Etheridge); Reed, p.14.

1937 S. andersoni; Öpik, p.41.

1947 Scutellum (Scutellum) andersoni, N & E; Prantl & Přibyl, p.56.

1974 Bronteus andersoni Eth & Nich; Kobayashi & Hamada, p.22,63.

non1889 Bronteus Andersoni Eth. jun. et Nich.; Toll, p.41, pl.3, fig.5.

Lectotype. Selected herein; HM A138, Pl.1, fig.15, internal mould of cranidium with 9 thoracic segments; figured Nicholson & Etheridge 1879, pl.12, fig.5; from Wood Burn Formation, Locality 22 (Penkill).

Paralectotypes. From type locality: BM In22651 (Pl.2, fig.6), figured Nicholson & Etheridge 1879, pl.12, fig.4, pygidium; BM In22650 (Pl.1, fig.17) pygidium used with another specimen, now apparently lost, to construct Nicholson & Etheridge 1879, pl.12, fig.3.

Material, localities and horizons. From type locality: BM In26652, slab with 2 cranidia (Pl.1, fig.14, Pl.2, fig.3) and 2 pygidia (Pl.1, fig. 16, Pl.2, fig.2), figured Reed 1904 pl.12, figs.8-11, GSM 32980 (Pl.2, fig. 4), SM A35164 (Pl.2, fig.1), cranidia; BM In22653,4, BM In22655 (Pl.2, fig. 5), BM In22656,7, GSM 4265, SM A35163, HM A68/1-3, HM A67 (Pl.2, fig.7), GSM 32979, RSM 1889.91.5 (7 specimens), GSE 711,2, pygidia. From Wood Burn Formation, Locality 21: BM In22658, GSE M2650[a], pygidia.

<u>Diagnosis</u>. Cranidium only very gently convex, 1½ times wider (tr.) than long (sag.). Glabellar lobe parallel-sided for posterior 1/3, expanding rapidly anteriorly. 1g, 2g and 3g muscle impressions separate. Occipital muscle impression not well defined. Anterior border short (sag. and exsag.), present in front of glabella. Fixed cheek wide (tr.). Pygidium with 7 pairs of ribs and non-bifurcate median rib, all carinate.

<u>Dimensions of lectotype</u>. Cranidial sagittal length, 9.0mm; cranidial maximum width, 12.0mm.

<u>Description</u>. Cranidium 1½ times wider (tr.) than long (sag.). Glabellar lobe very gently convex, posterior ½ parallel-sided and 1/3 width (tr.) of cranidium, expanding anteriorly to almost maximum width of cranidium. Occipital ring just over 1/3 width (tr.) of cranidium, 1/6 length (sag.) of cranidium for median ½ of ring, laterally decreasing in length (exsag.), curved in outline posteriorly. Occipital furrow distinct, transverse for median ½ of glabella width, shallowing behind occipital muscle impression. Occipital muscle impression, subtriangular in outline not delimited anteriorly. 1g oval in outline, as long (exsag.) as occipital ring. 2g transverse, slit-like, positioned opposite change in direction of axial furrow. 3g similar to 2g but slightly wider (tr.), obliquely aligned, as close to axial furrow as 2g, positioned 1/3 of distance between 2g and anterior margin. Axial furrow exsagittal for posterior ½ of length, then turning through 50° towards anterolateral corner of cranidium, dying out before reaching margin. Anterior border very short (sag.). Anterior border furrow short (sag.), increasing in length (exsag.) laterally producing flat anterolateral area into which axial furrow merges. Fixed cheek approximately 1½ times longer (exsag.) than width (tr.) across palpebral lobes, narrowing anteriorly. Lateral muscle impression small, circular in outline, positioned opposite palpebral lobe. Palpebral lobe semielliptical in outline, 1/3 length (exsag.) of cranidium, anterior limit opposite anterior limit of 1g, posterior limit opposite occipital furrow. Posterior border not distinctly preserved. Furrows and muscle impressions without

sculpture. All other surfaces with terrace 'ridges'; on anterior part of glabellar lobe and anterior part of fixed cheek, parallel to anterior margin; on posterior part of fixed cheek, diagonally aligned; on occipital ring, subparallel to occipital furrow; indistinct on posterior part of glabellar lobe.

Free cheek, rostral plate and hypostome unknown.

Only 9 thoracic segments known. Axial ring convex, equal in length (sag.) to pleura, approximately 1/3 width (tr.) of segment. Pleura flat and parallel-sided, lateral ½ of known width bent slightly ventrally, lateral limit unknown. Axial ring with terrace 'ridges' curved forward sagittally; pleura with terrace 'ridges' exsagittally aligned.

Pygidium as for K. cunctatum except that; pygidial axis more distinctly delimited posteriorly, no evidence of axial rings, and median rib and 7 paired ribs are carinate.

Discussion. K. andersoni is similar to K. parvispina Šnajdr (1960, p.73, pl.9, figs.13,14; text-fig.24), from the Kopanina Formation (Ludlow) of Kosov, near Králův Dvůr, Czechoslovakia. The relatively long parallel-sided posterior part of the glabella and the short anterior border of the cranidium are especially similar. However, they differ in that parvispina has cranidial axial furrows which die out opposite 3g and has a differently shaped 2g muscle impression.

The course and length of the axial furrows of andersoni is similar to that of 'Scutellum estonicum' (sensu Öpik 1937, pl.5, fig.2, non pl.9, fig.4; non Schmidt 1894), in that both almost reach the anterior margin. However, the Girvan form has a much wider (tr.) fixed cheek, has an even shorter anterior border and has a wider posterior portion of the glabellar lobe.

Prantl & Přibyl (1947, p.55) grouped a number of species around Scutellum (Scutellum) planum (Hawle & Corda, 1847). The characters by which they distinguished members of this group were; the "strikingly" broad preglabellar field and the "strikingly" large, semielliptical pygidium.

Curiously, Prantl & Přibyl (Ibid., p.56) included andersoni in this group without giving a reason. The very small anterior border and the lack of knowledge of the relative length of the pygidium to the rest of the dorsal shield should have excluded andersoni from this group.

The carination of the pygidial ribs is a feature also present in K. angusticosta Kobayashi & Hamada 1974 (p.70, pl.5, figs.3-6) from the Wenlock - lower Ludlow of Japan and K. borealis Poulsen 1934 (Raasch et al., 1961, fig.5:10) from Cape Schuchert Formation, Cape Schuchert, Greenland. K. andersoni differs from the former species in that the Japanese form has paired ribs which are more asymmetrical and the pygidial axis is more inflated. K. andersoni differs from the Greenland form in that the pygidial doublure extends further forward and the axial furrows of the cranidium diverge more.

Nicholson & Etheridge (1879, p.163) described andersoni as possessing "seven (?) transverse grooves" on the central section of the pygidial axis. These they took to be segments. Examination of andersoni pygidial axes has revealed no segmentation and it must be assumed that Nicholson & Etheridge were looking at terrace 'ridges' when they described "transverse grooves".

A pygidium attributed to "Bronteus andersoni" was recorded from Kotelny Island, Siberia by Toll (1889, p.41). Toll described this pygidium as andersoni because it had 7 axial rings, 7 pairs of radiating ribs with a median rib, concentric lines as surface sculpture, but did not show trilobation of the axis. Toll stated that his specimen was identical to those figured by Nicholson & Etheridge (1879, pl.12, figs.3,4). The lack of trilobation of the pygidial axis, the distinct axial rings, the pointed posterior extent of the pygidial axis, the non-carination of ribs and a more rapidly expanding posterior median rib separates the Siberian form from andersoni.

Genus Opsypharus gen. nov.

Name. Greek 'ope', meaning hole and 'sypharus', meaning wrinkled skin; pertaining to the surface sculpture.

Type species. Illaenus (Bumastus) Maccallumi n. sp. Salter 1867, p.210, pl.28, fig.1, pl.30, figs.2,3; from Mulloch Hill Formation (early Llandovery), Girvan, Strathclyde Region, Scotland.

Other species. O. depressus (Kiaer, 1908); pygidia Type C, D [= O? longicaudatus (Kiaer, 1908)] and E of Whittard 1940.

Stratigraphical range. Llandovery to Ludlow, Silurian.

Diagnosis. Effaced Scutelluidae of low convexity. Glabellar muscle impressions very weakly defined. Anterior pit with small granule inside, and anterior granule of cranidium present. Anteriorly axial furrow reaches anterior pit. Posteriorly axial furrow originates adjacent to apodemal pit exsagittally in line with most anterior part of palpebral lobe. Small median granule close to posterior margin. Fixed cheek narrow. Rostral plate without rostral flange. Thorax of at least 9 (?10) segments. Pygidium subtriangular in outline with concave border depression. Doublure of equal length as the concave border.

Discussion. Opsypharus can be distinguished from other genera with similar features by the relative flatness of the cranidium. The fact that the axial furrows die out at the anterior pit separates Opsypharus from Goldillaenus Schindewolf, 1924 and from Illaenoides Weller, 1907. In the latter there is no anterior pit and the axial furrows reach, or apparently reach, the anterior margin. Illaenoscutellum Kobayashi & Hamada 1974 (p.69) has a cranidial convexity similar to Opsypharus. Illaenoscutellum is known only from one poorly preserved cranidium (I. platiceps Kobayashi & Hamada 1974, p.70, pl.1, fig.1; text-fig.4C). However, the Japanese form differs in the course of the axial furrow and the presence of an occipital ring.

Opsypharus differs from Failleana Chatterton & Ludvigsen, 1976, here placed in the Scutelluidae, in that it is slightly less inflated, the axial furrows definitely die out at the anterior pit, the pygidium is relatively much longer (sag.) than wide (tr.), possesses a pygidial sagittal ridge and has a narrower pygidial doublure.

Opsypharus maccallumi (Salter, 1867) Pl.2, figs.8-15, Pl.3, figs.1-14.

v*1867 Illaenus (Bumastus) Maccallumi Salter, p.210, pl.28, fig.1, pl.30, figs.2,3.

1868 ?Bumastes M'Cullumi Salter; Bigsby, p.42.

1868 Illaenus M'Cullumi Salter; Ibid., p.55.

1877 Illaenus (Bumastus) Maccallumi Salt; Woodward, p.41.

v.1879 I. macallumi [sic] Salt; Nicholson & Etheridge, p.162, pl.12, fig. 2.

1882 I. (Bum.) Maccallumi SALT; Holm, p.38 [List]

1882 I. Maccallumi Salter, 1867; Ibid., p.54 [List].

1883 I. (Bum.) Maccallumi SALT; Holm, p.38 [List]

1883 I. Maccallumi Salter, 1867; Ibid., p.54 [List].

1899 Illaenus (Bumastus) Maccallumi (Salt); Peach & Horne, p.529 [List].

1899 Illaenus (Bumastus) Macallumi [sic](Salt.); Ibid., p.673 [List].

v.1904 I. macallumi [sic] Salt; Reed, p.65, pl.9, figs.8,9.

?1912 Illaenus aff. Macallumi [sic] Salter; Reed, p.17 [List], p.20.

1925 Bumastus Macallumi [sic] Salt; Warburg, p.141.

1931a Illaenus (Bumastus) macallumi [sic] Salt; Reed, p.13.

1940 B. macallumi [sic] (Salter, 1867); Whittard, p.287.

1945 Bumastus maccullumi [sic] Salter; Begg, p.110.

1962 Bumastus maccallumi Salt.; Maksimova, p.68.

?1971 Illaenus aff maccalumi [sic]Salter; Kobayashi & Hamada, p.94 [List].

?1974 Illaenus aff. maccalumi [sic] Salter; Kobayashi & Hamada, p.20 [List].

non1928 Bumastus Maccallumi (?) Salt; Weber, p.248, pl.22, figs.3,5.

Lectotype. Selected herein; OUM C5, Pl.2, fig.12, disarticulated internal mould of dorsal shield; figured Salter 1867, pl.30, fig.3; from

Mulloch Hill Formation, Mulloch (Localities 1-7).

Paralectotypes. From type locality: OUM C4 (Pl.3, figs.7a,b), figured Salter 1867, pl.30, fig.2, GSM 35906 (Pl.3, fig.13), figured Salter 1867, pl.28, fig.1, pygidia.

Material, localities and horizons. This species in very well represented in all the major palaeontological collections of the British Isles and no attempt is made to give a comprehensive list. Details of specimens figured herein are as follows. From Mulloch Hill Formation, Mulloch Hill (Localities 8 or 9): HM A9031 (Pl.3, figs.4a,b) complete dorsal shield; BM In21795 (Pl.3, fig.1), figured Reed 1904, pl.9, fig.8, cranidium; BM In21797 (Pl.2, figs.10a,b), figured Nicholson & Etheridge 1879, pl.12, fig.2, BM In21796a (Pl.3, fig.6), figured Reed 1904, pl.9, fig.9, pygidia. From Mulloch Hill Formation, Locality 9: BM In47723 (Pl.3, fig.12) pygidium. From Newlands Formation, Locality 14: BM In43173 (Pl.2, fig.8), HM A4790 (Pl.2, fig.9), BM In43183 (Pl.2, fig.11), BM In43187 (Pl.2, fig.15), BM In43174 (Pl.3, figs.2,10), HM A4798 (Pl.3, fig.8), cranidia; HM A9056 (Pl.2, fig.13), BM In43169 (Pl.3, figs.3a,b), free cheeks; HM A4813 (Pl.3, fig.5) rostral plate; BM In43191 (Pl.2, figs.14a,b), HM A4819 (Pl.3, fig.9), HM A4801 (Pl.3, fig.11), HM A4795 (Pl.3, fig.14), pygidia. Also the species is known from; Mulloch Hill Formation, Localities 6 and 10; and Newlands Formation, Locality 11.

Diagnosis. Opsypharus with well defined lateral muscle impression and distinct anterior pit. Eye crescentic in outline. Sculpture of whole dorsal surface with only very faint terrace ridges.

Dimensions of lectotype. Cranidial sagittal length, 9.0mm; cranidial maximum width, 10.0mm; pygidial sagittal length, 12.0mm; pygidium maximum width, 12.0mm; reconstructed total sagittal length of whole specimen, 28.0mm.

Description. Cranidium fractionally longer (sag.) than width (tr.) across palpebral lobes. Cephalic axis (Jaanusson 1954, p.552) with no visible muscle impressions, 5/6 width (tr.) of cranidium at posterior border, 2/3 this width opposite palpebral lobes where axis narrowest and as wide at anterior pit as at posterior margin. Posterior section of axial furrow shallow, curving backwards to adjacent to apodemal pit (seen on internal mould), exsagittally located level with most anterior part of palpebral lobe. Anterior section of axial furrow curving abaxially forward to anterior pit. Anterior pit positioned 1/5 length (exsag.) of cranidium from anterior edge, with central granule. Anterior granule of cranidium sometimes present. Median granule positioned close to posterior margin of cephalic axis. Fixed cheek elongate. Lateral muscle impression oval in outline, 1/7 length (exsag.) of cranidium, adjacent to axial furrow and opposite palpebral lobe, better defined on internal moulds. Palpebral lobe subsemicircular in outline, ¼ length (exsag.) of cranidium. Anterior portion of facial suture curving forwards abaxially until almost at anterior border when becomes adaxially directed. Posterior portion of facial suture curving strongly abaxially cutting the posterior border at very acute angle. Sculpture visible only near to anterior margin, composed of terrace ridges with faint punctae, internal mould without sculpture. Free cheek 1½ times longer (exsag.) than wide (tr.). Broad, slightly raised lateral border delimited by ill-defined furrow approximately 1/3 width (tr.) of cheek, 3 times wider (tr.) posteriorly than anteriorly, corresponds to extent of doublure. Raised lateral border with terrace ridges subparallel to anterolateral margin and with punctae. Doublure with 6-8 terrace ridges parallel to lateral edge; articulation facet as broad (exsag.) groove at genal angle.

Rostral plate (internal mould only known) approximately 3 times wider (tr.) than long (sag.); anterior margin curved in outline; hypostomal suture straight, 1/6 width (tr.) of plate; connective suture slightly oblique at 20° to transverse; terrace 'ridges' arranged subparallel to anterior and posterior margins.

Thorax with 9, possibly 10 segments, like those of Bumastus? vulsus sp. nov. (see Page 17).

Pygidium slightly longer in length (sag.) and width to cephalon, subtriangular in outline, slightly wider (tr.) than long; gently convex over central region with slightly concave border. No axis defined. Antero-lateral corner with articulation facet 1/5 length (exsag.) of pygidium. External surface with no sculpture except for pygidial sagittal ridge visible from midlength (sag.) of pygidium to posterior edge. Doublure ventrally convex extending adaxially only as far as concave border, with 12 terrace ridges subparallel to edge of pygidium.

Discussion. Weber (1928, p.248, pl.22, figs.3,5) described and figured a pygidium from the Kuznetzk Basin which he believed to be maccallumi. Although the figures are poor the pronounced semicircular outline of the anterior margin reveals that it is not conspecific with the Girvan form.

The cranidium and two pygidia figured as Illaenus arenaceus Whittard (1938, p.92, pl.2, fig.4-6) from the Llandovery of Shropshire and perhaps the cranidium (Ibid., pl.2, fig.1) assigned to Illaenus aemulus, show some similarities to O. maccallumi. However, the cranidia differ in that the posterior portion of the axial furrow is wider (tr.) and deeper, and the lateral muscle impression is smaller and lies astride the axial furrow, in Whittard's specimens. The pygidium of maccallumi is longer (sag.) and narrower (tr.) and the posterior margin is more pointed in outline than the Shropshire form.

The cranidium of maccallumi is similar to the "mature" cranidium of Failleana calva Chatterton & Ludvigsen 1977 (p.38, pl.6, figs.1-42), from the South Nahanni River area (Middle Ordovician), District of MacKenzie, Canada. However, the Canadian form differs in the narrow (tr.) free cheek, the relatively shorter and wider pygidium and a longer (sag.) pygidial doublure.

Family ILLAENIDAE Hawle & Corda, 1847

Diagnosis. Greatly convex cephalon, small or absent eyes, pygidium often shorter (sag.) than cephalon, usual presence of pygidial sagittal ridge, horizontal articulating flange of pleura, presence of articulating half rings and the often modified margin of the pygidial doublure into prongs.

Genera included. *Thaleops*? Conrad, 1843; *Stenopareia* Holm, 1886; *Nanillaenus* Jaanusson, 1954; *Panderia* Volborth, 1863; *Ectillaenus* Salter, 1867; *Cekovia* Šnajdr, 1956; *Zbirovia* Šnajdr, 1956; *Zdicella* Šnajdr, 1957; *Ottenbyaspis* Bruton, 1968a.

Discussion. See discussion of Illaenacea herein Page 13.

Genus *Stenopareia* Holm, 1886.

Type species. Original designation; *Illaenus linnarssonii* Holm, 1882, p.103, pl.4, figs.13-27, pl.5, figs.1-8, pl.6, fig.15; from the Leptaena Limestone (Late Ordovician) of Dalarne.

1. *Stenopareia thomsoni* (Salter, 1867) Pl.4, figs.11-15, Pl.5, figs.1-5.

v.1851 *Illaenus* sp. ind.; Salter, p.171, pl.9, fig.3.

1852 *Illaenus rosenbergi*; McCoy, p.368 [List].

v*1867 *Illaenus* (*Dysplanus*) *thomsoni*, Salter; Salter, p.188, pl.28, figs. 2,3, *non* fig.4, pl.30, figs.8,10, *non* fig.9.

1868 *Illaenus Thomsoni*, Salter; Bigsby, p.56.

1873 *Illaenus Thomsoni* Salter; Salter, p.77,86(*pars*).

?1876 *Illaenus Rosenbergii* D'Eichwald; Armstrong *et al.*, p.16.

1876 *Illaenus nexilis*, Salter; *Ibid.*, p.16.

1877 *Illaenus* (*Dysplanus*) *Thomsoni*, Salt.; Woodward, p.42.

v.1879 *Illaenus Thomsoni*, Salter; Nicholson & Etheridge, p.156, pl.11, fig.9.

1882 *I. Thomsoni*, Salter 1851; Holm, p.49 [List].

1883 *I. Thomsoni*, Salter 1851; Holm, p.49 [List].

1891 *I.* (*Dysplanus*) *thomsoni*, Salter; Woods, p.146 [List].

?1899 *Illaenus* (*Bumastus*) *Bowmani* (Salt.); Peach & Horne, p.529 [List].

1899 *Illaenus* (*Dysplanus*) *Thomsoni* (Salt.); *Ibid.*, p.529,530 [List].

1899 *Illaenus Thomsoni* (Salt.); *Ibid.*, p.689 [List].

v.1904 <u>Illaenus</u> <u>thomsoni</u>, Salter 1866; Reed, p.70, pl.10, figs.6,7.

1925 <u>Illaenus</u> <u>Thomsoni</u>, Salt; Warburg, p.122.

1940 <u>Illaenus</u> <u>thomsoni</u> Salter, 1867; Whittard, p.285.

1945 <u>Illaenus</u> <u>thomsoni</u>, Salter; Begg, p.110.

?1962 <u>Stenopareia</u> <u>thomsoni</u> Salter; Maksimova, p.66, pl.9, figs.3a,b.

?1971 <u>Stenopareia</u> <u>thomsoni</u> (Salter); Kobayashi & Hamada, p.23,47.

<u>Lectotype</u>. Selected herein; RSM 1967.58.46, Pl.5, fig.1a, internal mould of almost complete large dorsal shield, counterpart OUM C3, Pl.5, fig.1b, figured Salter 1867, pl.30, fig.8; from Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

<u>Paralectotypes</u>. From type locality: GSM 35907 (Pl.4, fig.11), figured Salter 1851, pl.9, fig.3, refigured Salter 1867, pl.28, fig.2, incomplete dorsal shield. From Mulloch Hill Formation, Mulloch Hill (Localities 8 or 9): GSM 35908 (Pl.4, fig.14) figured Salter 1867, pl.28, fig.3, SM A34883, (Pl.4, fig.15) figured Salter 1867, pl.30, fig.10, pygidia.

<u>Material</u>, <u>localities</u> <u>and</u> <u>horizons</u>. From the type locality: BMIn21857, In21889,90, RSM 1859.33.220, pygidia. From Mulloch Hill Formation Locality 6: BM In21822 (Pl.5, figs.5a,b), figured Reed 1904, pl.9, fig.13, rostral plate; BM In21823,4, thoracic segments; GSE M1988, pygidium. From Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9): BM In21864 (Pl.5, fig.4) figured Reed 1904, pl.10, fig.6, BM In21861 (Pl.5, fig.3), figured Reed 1904, pl.10, fig.7, free cheeks; BM In21858 (Pl.4, fig.12), figured Nicholson & Etheridge 1879, pl.11, fig.9, HM A4728, SM A34882 (Pl.5, fig.2) listed McCoy (1852, p.368) as <u>Illaenus</u> <u>rosenbergi</u>, SM A34881, A34879, BM In21857, pygidia; BM In21863 (Pl.4, fig.13) 9 thoracic segments.

<u>Diagnosis</u>. Dorsal shield approximately 2½ times longer (sag.) than wide (tr.). Cranidial axial furrow shallow with no evidence of muscle impressions on the cephalic axis. Lateral muscle impression long (exsag.) positioned anterior to palpebral lobe. Palpebral lobe small, twice its own length from posterior margin. Rostral plate long (sag.) with 15 terrace 'ridges'. Pygidium as long (sag.) as wide (tr.). Anterior projection of

pygidial doublure cuspate medially, with 15-20 terrace 'ridges'.

Dimensions of lectotype. Total sagittal length, 145.0mm; pygidial sagittal length, 60.0mm; pygidial maximum width, 65.0mm; cranidial maximum width, 54.0mm.

Description. Cranidium not well known, actual dimensions not measurable, but not much longer (sag.) than wide (tr.). Axial furrows shallow, reaching forward for about ½ length (exsag.) of cranidium, almost straight posteriorly curving abaxially then adaxially for anterior ½ of length. Posterior margin transverse. Palpebral lobe very small in length and width, positioned approximately 1/6 length (exsag.) of sagittal length from posterior margin. No surface sculpture visible on internal or external surfaces.

Free cheek not well known but very gently convex, rounded in outline posteriorly, position of eye not known. No surface sculpture known. Anteriorly deflected at right angles to plane of free cheek to produce doublure, with 12-15 terrace 'ridges'.

Rostral plate twice as wide (tr.) as long (sag.). Anterior margin gently curved in outline. Hypostomic suture outlining blunt point medially. Connective suture obliquely aligned at approximately 30° to exsagittal. Terrace 'ridges' not greatly raised, approximately 15 in number, parallel with transverse margins.

Thorax with 9 segments. Central axis of thoracic segment over 1/3 width (tr.) of total thoracic width. Pleura smooth with no pleural furrow, flat except where ridged adjacent to axial furrow.

Pygidium as wide (tr.) as long (sag.) gently convex. Median arch just over ½ width (tr.) of pygidium. Articulating facet 2/3 width (tr.) of median arch. Dorsal surface with no evidence of sculpture. Doublure broad, well over ½ length (sag.) of pygidium, extends forward medially as short, wide projection, cuspate in outline; faint wide median ventral ridge. Doublure traversed by terrace 'ridges' subparallel to margins.

Discussion. Reed (1904, p.66) recorded that Stenopareia nexilis (Salter, 1867) along with thomsoni could be found at Localities 8, 6, 18 and 22 (Rough Neuk, Craigens Quarry, Woodland Point and Penkill respectively). S. nexilis differs from thomsoni in that it is much more convex and a posterior border to the pygidium is very well defined. The syntypes of nexilis (Salter 1867, pl.30, figs.4,5) were given the horizon and locality as the "Llandovery schists of Mullock [sic]" in the species description (Salter 1867, p.191) but in the description of plate 30 the horizon and locality are given as the "Llandovery rocks of Drummuck". The specimen represented by plate 30, fig.5 is not traceable. However, a comparison of specimen OUM C2 (pl.30, fig.4) with the preservation and matrix of Ordovician and Silurian specimens of Girvan indicates that it is from Drummuck and is of Drummuck Group, Ashgill, Ordovician age. R.P.Tripp (pers. comm.) agrees with this opinion.

In the collections of the Sedgwick Museum, Cambridge are a number of Stenopareia specimens from "The Frolic", Haverfordwest, Mudstone Formation, (upper Ashgill to early Llandovery), Haverfordwest, Dyfed (Cocks & Price, 1975). These are very similar to thomsoni. Unfortunately like the Girvan specimens, the Haverfordwest material is in the form of rather poorly presrved casts and moulds. Hence a close comparison between the forms is difficult. The anterior projection of pygidial doublures have a similar outline (ie. cuspate) and the two forms are very similar. In view of the preservation and lack of a good specimen the Haverfordwest form is here referred to as Stenopareia aff. S. thomsoni.

The two pygidia of thomsoni described and figured by Maksimova (1962, p.66, pl.9, figs.3a,b) from the Llandovery of the Siberian Platform appear very similar to the Girvan form. However, they cannot be compared because only the two pygidia are known and of these the pygidial doublure has not been revealed.

BM In21822 (Pl.5, figs.5a,b) from Locality 6 is described here as the only known rostral plate of S. thomsoni. This association is made on purely circumstantial evidence as thomsoni is the only species of Stenopareia known from other parts of the exoskeleton for that locality.

2. Stenopareia acymata sp. nov. Pl.5, figs.6,7,Pl.6, figs.1-5, Pl.23, fig.12.

Name. Greek 'akymatos', meaning calm; alluding to the pattern of the terrace ridges on the dorsal surface of the pygidium.

v.1879 Illaenus Rosenbergii, Eichwald (?); Nicholson & Etheridge, p.159, pl.11, fig.14.

v.1904 Illaenus aemulus, Salter var.; Reed, p.55 (pars), pl.8, figs.6-9.

1938 Illaenus aemulus; Whittard, p.89.

1945 I. aemulus, Salter; Begg, p.110 (pars).

Holotype. BM In21709 (Pl.5, figs.6a,b), dorsal shield, figured Reed 1904, pl.8, fig.7; from Woodland Formation, Locality 18.

Paratypes. From type locality: BM In21707 (Pl.6, fig.1), figured Reed 1904, pl.8, fig.8, BM In21706f, In21708, In44465, GSM 4234, 32978, HM A137 (Pl.23, fig.12), figured Nicholson & Etheridge 1879, pl.11, fig.14 as pygidium of Illaenus Rosenbergii, cranidia; BM In21706c (Pl.6, fig.4) figured Reed 1904 pl.8, fig.9, BM In21706d, In21828, In21876 (Pl.6, fig.5), free cheeks; BM In21706a (Pl.5, fig.7) figured Reed 1904, pl.8, fig.6, HM A4739 (Pl.6, figs.3a,b), BM In44488, In21706b, In21706e, RSM 1889.91.6, SM A35132 (Pl.6, fig.2), BM In21871,2, In44461, In44475, pygidia.

Diagnosis. Dorsal shield approximately 1½ times longer (sag) than wide (tr.). Cranidium larger than pygidium. Cranidial axial furrow shallow, muscle impressions poorly defined. Pygidium wider than long. Pygidial terrace ridges transverse for most part but directed anteriorly along mid-line. Anterior margin of doublure projected forward with almost transverse anterior edge.

Dimensions of holotype. Total sagittal length, 29.0mm; cranidial sagittal length, 14.5mm; cranidial maximum width, 17.0mm; pygidial sagittal length, 10.0mm; pygidial maximum width, 17.0mm.

Description. Cranidium strongly convex longitudinally, approximately as wide (tr.) as long (sag.). Cephalic axis with no visible muscle impressions, ½ width (tr.) of cranidium at posterior border. Axial furrows curved slightly adaxially, broad and shallow, 1/3 length (exsag.) of cranidial circumference terminating at position of lateral impression. Lateral impression indistinctly defined. Palpebral lobe about 1/7 length (exsag.) of cranidium, about its own length from posterior border. Anterior section of facial suture straight, running almost exsagittally forward. Posterior section of facial suture curving abaxially cutting posterior margin at acute angle. Sculpture,not clearly defined in any of the specimens, of sinuous terrace ridges subparallel to anterior and posterior edges, with punctae. Free cheek 1¾ times longer (exsag.) than wide (tr.), subtriangular in outline, widest part at midlength (exsag.). Surface flat except for raised eye lobe 1/5 length (exsag.) and ¼ width (tr.) of free cheek, oval in outline, positioned immediately anterior to doublure of posterior border. Surface very faintly sculptured laterally with terrace ridges subparallel to margin, with punctae. Doublure wide, 2/3 width of free cheek at widest part narrowing at anterior and posterior extent, with strongly raised terrace ridges.

Rostral plate and hypostome unknown.

Thorax of 9 segments. Axial region convex, 1/3 total width (tr.) of thorax posteriorly, expanding to ½ total width (tr.) anteriorly. Pleura straight for ½ width (tr.) bent posteriorly and tapering to point for remainder of width. Sculpture of faint terrace ridges subparallel to transverse margins.

Pygidium 1½ times wider (tr.) than long (sag.), almost semicircular in outline. Median arch 2/5 width (tr.) of pygidium at widest point. Articulating facet 1/5 width (tr.) of pygidium. Sculpture as fine sinuous terrace ridges all over surface area except just posterior to median arch extending to mid-area of pygidium, subparallel to pygidial margins and produced slightly anteriorly at sagittal line, with punctae. Doublure, 1/3 length (exsag.) of pygidium, with forward almost transverse edged projection, approximately ¼ width (tr.) of pygidium, with terrace 'ridges' parallel to posterior edge. Internal mould without sculpture.

Discussion. See discussion after S. catathema sp. nov.

3. Stenopareia glochin sp. nov. Pl.6, figs.6-12.

Name. Greek 'glochin', meaning point of an arrow; pertaining to the outline of the anterior edge of the pygidial doublure.

Holotype. YH NW305, Pl.6, fig.10, internal mould of pygidium; from Newlands Formation, Locality 14 (Newlands Farm).

Paratypes. From type locality: HM A4727, A1011, A4725 (Pl.6, fig. 9), cranidia; BM In43170 (Pl.6, fig.7), In21887, HM A570, rostral plates; HM A4723, YH NW306 (Pl.6, fig.12), BM In21890, YH NW297, BM In43167 (Pl.6, fig.11), pygidia. From Mulloch Hill Formation, Locality 8: YH R7a,b (Pl.6, fig.6, cranidium; BM In21862, rostral plate. From Newlands Formation, Locality 11: HM C28 (Pl.6, fig.8) cranidium. From Mulloch Hill Formation, Locality 10: YH G28, pygidium.

Diagnosis. Cranidium very convex. Lateral muscle impression well defined. Pygidium wider than long. Pygidial terrace ridges well defined directed anteriorly along midline. Pygidial doublure with anterior margin projected into median point.

Dimensions of holotype. Pygidial sagittal length, 18.0mm; pygidial maximum width, 25.0mm.

Description. Cranidium, only known as internal mould, as for S. acymata sp. nov. However, lateral muscle impression clearly defined as long as palpebral lobe, virtually crescentic in outline. Free cheek not known. Rostral plate 2½ times wider (tr.) than long (sag.); anterior margin curved in outline; connective sutures obliquely aligned at approximately 40° to exsagittal line. Rostral flange equal to width (tr.) of plate but of unknown length. Approximately 8-10 coarse terrace 'ridges' transversely aligned parallel with anterior margin.

Pygidium similar in convexity and outline to S. acymata. However, with terrace ridges on the dorsal surface almost transverse laterally but anteriorly directed along sagittal line producing $\wedge$ shape in outline. Anterior outline of doublure projected forward into single point.

Discussion. See discussion after S. catathema sp. nov.

4. Stenopareia catathema sp.nov. Pl.7, figs.1-12.

Name. Greek 'katathema', meaning accursed thing.

?1876 Illaenus Thomsoni Salter; Armstrong et al., p.16.

1879 Illaenus Bowmani, Salter; Nicholson & Etheridge, p.155 (pars).

v.1879 Illaenus aemulus, Salter (?); Ibid., p.157, pl.11, fig.10, pl.12, figs.12,13.

v.1879 Illaenus nexilis, Salter; Ibid., p.158 (pars), pl.11, fig.12, non figs.11,13.

1899 Illaenus (Dysplanus) aemulus (Salt.); Peach & Horne, p.536,673 [List].

?1899 Illaenus (Dysplanus) Thomsoni (Salt.); Ibid., p.536,673 [List].

?1899 Illaenus (Bumastus) Bowmani (Brong.); Ibid., p.536,673 [List].

?1899 Illaenus nexilis (Salt.); Ibid., p.536,673 [List].

?1899 Illaenus sp.; Ibid., p.536,673 [List].

v.1904 Illaenus aemulus, Salter 1867; Reed, p.54, pl.8, fig.5.

v.1904 Illaenus aemulus, Salter, var.; Ibid., p.55, pl.8, fig.10, non fig.11.

v.1935 Illaenus aemulus, Salter; Reed, p.25, pl.2, fig.9.

1938 Illaenus aemulus, Salter; Whittard, p.89.

1945 I.aemulus, Salter; Begg, p.110.

Holotype. BM In21712, Pl.7, fig.12, exfoliated pygidium with counterpart; figured Nicholson & Etheridge 1879, pl.11, fig.10, refigured Reed 1904, pl.8, fig.10; from Wood Burn Formation, Locality 22 (Penkill).

Material, localities and horizons. This species is well represented in the major palaeontological collections of the British Isles and no attempt is made to give a comprehensive list. Details of specimens figured herein are as follows. From type locality: GSM 32976 (Pl.7, figs.1a,b), BM In21713 (Pl.7, figs.2a-c), figured Nicholson & Etheridge 1879, pl.12, fig.13, BM In21868 (Pl.7, fig.4) figured Nicholson & Etheridge 1879, pl.12, fig.1, cranidia; BM In21870 (Pl.7, figs.5a,b) figured Nicholson & Etheridge 1879, pl.11, fig.12, BM In46638 (Pl.7, fig.3), rostral plates; BM In21702 (Pl.7, fig.12) figured Reed 1904 pl.8, fig.5, HM A936 (Pl.7, fig.10) figured Reed 1935 pl.2, fig.9, BM In46628 (Pl.7, fig.9), pygidia; BM In21714 (Pl.7, fig.7) figured Nicholson & Etheridge 1879, pl.12, fig.12, pygidium with segments. From Lower Camregan Grits, Locality 19: BM In21865 (Pl.7, figs.6a,b) doublure of free cheek. From ?Lauchlan Formation, Locality 23: GSM 70729 (Pl.7, fig.8) pygidium. This species is also collected from Wood Burn Formation, Localities 20, and 21.

Diagnosis. Cranidium greatly convex. Axial furrows shallow and wide. Eye small, near to posterior border. Rostral plate somewhat spindle-shaped in outline with 10 terrace 'ridges'. Pygidium wider than long, terrace ridges well defined and lie enechelon along sagittal line. Anterior margin of pygidial doublure produced into anterior projection.

Dimensions of holotype. Pygidial sagittal length, 20.0mm; pygidial maximum width, 32.8mm.

Description. Cranidium essentially as for S. acymata but with: palpebral lobes slightly wider (tr.); axial furrows wider (tr.); distinct terrace ridges posteriorly projecting forwards becoming transverse at mid-length, not preserved anteriorly. Free cheek dorsal surface unknown. Doublure wide anteriorly decreasing in width posteriorly, sickle-shaped in outline, with 11-12 coarse terrace 'ridges' parallel to margins.

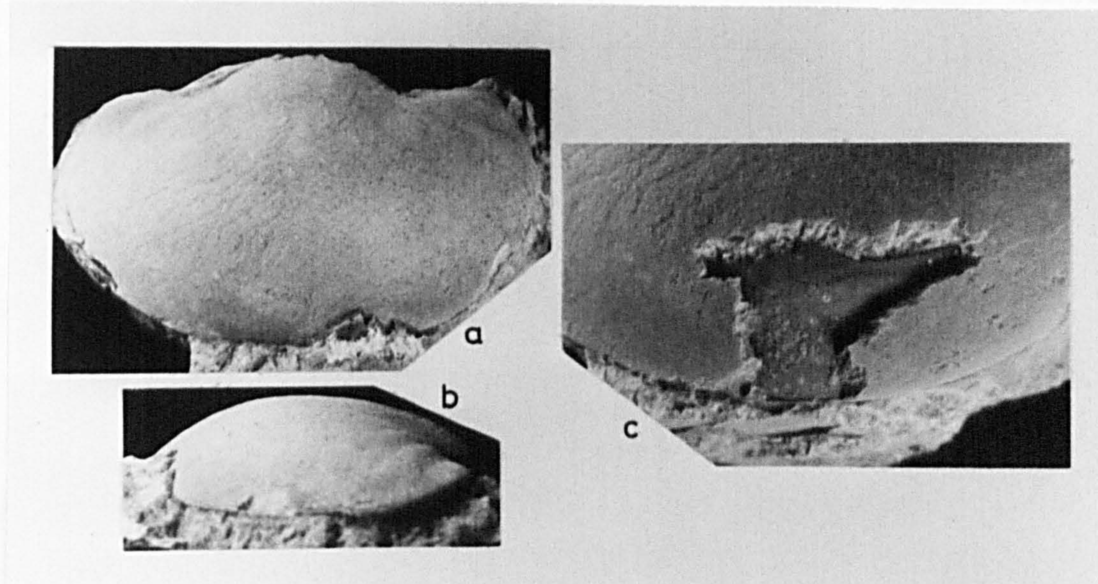
Rostral plate approximately 2½ times wider (tr.) than long (sag.). Anterior margin gently curved in outline. Posterior flange bent dorsally parallel to ventral surface for at least ½ length (sag.) of plate. Connective sutures obliquely aligned at about 45° to exsagittal. Terrace 'ridges' distinctly raised, approximately 12 in number, parallel to transverse margins.

Hypostome unknown.

Thorax with 9 segments. Axial region convex, 1/3 width of thorax, decreasing in width posteriorly. Pleura parallel-sided and horizontal for adaxial ½, deflected ventrally and slightly posteriorly for remainder of width.

Pygidium 1 3/5 wider (tr.) than long (sag.). Median arch 3/5 width (tr.) of pygidium. Articulating facet 1/5 width (tr.) of pygidium. Sculpture as coarse widely spaced terrace ridges mostly running obliquely forwards across pleural field to sagittal line where project anteriorly in ∧-shape, dying out at posterior margin. No evidence of punctae in specimens available. Doublure up to 1/3 length (exsag.) of pygidium sagittally projected anteriorly to point at approximately ½ length (sag.) of pygidium; with transverse 'ridges' subparallel to posterior margin, slight angulation medially, no terrace 'ridges' associated with projected part of doublure. Internal mould of pygidium without sculpture.

Discussion. The three new species of Stenopareia described above are very similar to each other and are closely allied to Stenopareia aemula (Salter 1867, p.187, pl.28, fig.5) from the Pentamerus Beds (Fronian) Shropshire. Reed (1904) regarded the specimens referred to these three new species to belong to Illaenus aemulus (Reed 1904, p.54, pl.8, fig.5) or to its "variety" Illaenus aemulus var. (Reed 1904, p.55, pl.8, figs.6-11). The cranidium of S.aemula is not known definitely and so the distinction between these three Girvan species and the Shropshire form must rely on the pygidia. S. aemula has coarse terrace 'ridges' over the surface of the pygidium which are directed strongly forward medially. The anterior projection of the pygidial doublure is a short (sag.) single point (Text-fig.21e). S. acymata differs from aemula in the outline of the anterior projection of the doublure in that it is cuspate. The terrace ridges are much less coarse and are almost transverse with no anterior projection medially. S. glochin differs from aemula in that the forward projection of the pygidial doublure, although a single point, is longer (sag.), the anterior margin of the median arch is more transverse and the terrace ridges are more anteriorly directed medially. S. catathema differs from aemula



TEXT-FIG.21. Holotype pygidium of Stenopareia aemula (Salter, 1867), OUM 35991, figured Salter 1867, pl.28, fig.5, refigured Whittard 1938, pl.2, fig.2; from ?Norbury, Pentamerus Beds (Fronian), Shropshire. a, internal mould, dorsal view showing coarse terrace 'ridges', x1.25; b, internal mould, lateral view, x1.25; c, dorsal view with matrix removed to reveal anterior projection of doublure, x2.5.

and glochin in that the pygidium is shorter (sag.) and wider (tr.) and the terrace ridges are directed more anteriorly along the median line. The anterior projection of the pygidial doublure is a single point but is much longer (sag.) than either aemula or glochin.

Dean (in press, p.101) describes S. linnassonii (Holm, 1882) from the Chair of Kildare Limestone (Upper Ordovician), Eastern Ireland. He includes in this species pygidia (BM It1512, figured Dean, Ibid., pl.49, figs.4,7,8,14; BM It1548, figured Dean, Ibid., pl.49, figs.2,3,5) which have a single pointed anterior projection of the anterior margin of the pygidial doublure consistent with the type of the species; and also a pygidium (BM It1545, figured Dean, Ibid., pl.49, figs.1,6,9,13) which has 3 anterior projections of the doublure. BM It1543 (figured Dean, Ibid., pl.50, figs.4,6,8) also a pygidium, although from a different locality to the former pygidia, is regarded by Dean (Ibid., p.105) to be similar to S. linnarssonii but this specimen has a wide blunt forward projection of the pygidial doublure reminiscent of S. thomsoni. Dean (Ibid., p.105) considers that the modification of the anterior margin of the pygidial doublure represents intraspecific variation within a species such as S. linnarssonii. The present author with a larger sample of Stenopareia material available from Girvan has detected no such variation within what she considers to be three distinct species, described herein.

S. thomsoni occurs with glochin at Locality 8. The pygidium of the latter can be distinguished from the pygidia of thomsoni but the cranidia (mostly internal moulds) are difficult to distinguish. The only criterion found to spearate the species is that the palpebral lobe of thomsoni, which is smaller, is placed relatively further forward on the cranidium.

Some large pygidia of S. acymata look similar to thomsoni but the former has more clearly defined terrace ridges and has more terrace 'ridges' on the pygidial doublure.

A pygidium of S. acymata (HM A4739, Pl.6, figs.3a,b) has a flattened area anteromedially, delimited by a change of slope, ½ width (tr.) of median arch, tapering posteriorly for under ¼ length (sag.) of pygidium, then expanding posteriorly at a lesser rate and then dying out at about ½ length (sag.) of the pygidium. This feature is seen on both internal mould and latex rubber cast of the external mould of the specimen. It is conceivable that this area is representative of the true pygidial axis. The internal mould reveals at least two pairs of flattened ridges which radiate outwards from the change of slope at the posterior part of this 'axis' to the innermost extent of the doublure.(Pl.6, fig.3a). These radiating structures can also be seen on specimens of pygidia (BM In21702, Pl.7, fig.12; RSM 1889.91.2) of catathema. Here at least five pairs of 'ridges' can be detected.

The rostral plates of thomsoni and glochin are distinguishable in that the former has 15 terrace 'ridges' whereas the latter has only 8-10. Rostral plates have been assigned to catathema because of their relatively large size in comparison with the smaller and morphologically different rostral plates assigned to Bumastus? vulsus sp. nov., which occurs at the same localities as catathema (see also Page 21).

Family PROETIDAE Salter, 1864

/= Prionurides Hawle & Corda, 1847; = Proetiden Hawle & Corda, 1847/

Subfamily PROETINAE Salter, 1864

/nom. transl. Přibyl, 1946 (ex Proetidae Salter, 1864)/

Genus Cyphoproetus Kegel, 1927

Type species. Subsequent designation by Přibyl 1946a, p.15; Cyphaspis depressa Barrande 1846, p.60; from Liteň Formation (Wenlock Series), Lištice, near Beroun, Prague district, Czechoslovakia.

Diagnosis and discussion. See Owens (1973a, p.27).

1. Cyphoproetus externus (Reed, 1935) Pl.8, figs.1-6,9.

?1899 Proetus sp.; Peach & Horne, p.529 /List/.

v.1904 Proetus stokesi (Murchison) 1839; Reed, p.79, pl.11, figs.10,11.

v*1935 Proetus (Cyphoproetus) externus Reed, p.42, pl.2, fig.15.

v.1973a Cyphoproetus externus (Reed, 1935); Owens, p.32, pl.6, figs.6-8.

Holotype. By monotypy: HM A1032, internal mould of cranidium, figured Reed 1935, pl.2, fig.15, refigured Owens 1973a, pl.6, figs.6a,6; from Newlands Formation, Locality 14 (Newlands Farm).

Material, localities and horizons. This species is represented in the major British palaeontological museums and no attempt is made to give a comprehensive list. Details of specimens figured herein are given as follows. From type locality: BM In21955 (Pl.8, fig.1), figured Reed 1904, pl.11, fig. 11, refigured Owens 1973a, pl.6, fig.8, complete internal mould; BM In21953 (Pl.8, fig.2) figured Reed 1904, pl.11, fig.10, refigured Owens 1973a, pl.6, fig.7, partially enrolled individual; YH NW431 (Pl.8, fig.4) cranidium; YH NW445 (Pl.8, fig.6) free cheek; BM In43730 (Pl.8, fig.5), pygidium. From Mulloch Hill Formation, Locality 10: YH G12/2 (Pl.8, fig.3), cranidium; LRMC 20 (Pl.8, fig.9), pygidium. This species has also been collected from

Mulloch Hill Formation, Localities 3, 6, and 8; and Woodland Formation, Locality 18.

Diagnosis, description and discussion. See Owens (1973a, p.32). Well preserved specimens show the sculpture of the dorsal shield as very fine terrace ridges arranged in a Bertillon pattern on the cranidium. This is a feature reminiscent of Decoroproetus Přibyl, 1946. Specimen YH G12/2 (Pl.8, fig.3), a small cranidium, shows rows of tiny granules which follow the Bertillon pattern of the terrace ridges found in larger specimens. This may indicate that the terrace ridges seen in some mature proetids originate as granules and later coalesce to form ridges. The majority of the specimens have suffered some distortion and there is a wide variety of form, from short-wide forms with a blunt outline to the anterior margin of the glabella to long-narrow forms with a rounded outline to the glabella.

2. Cyphoproetus pugionis sp. nov. Pl.8, figs.7,8,10,14.

Name. Latin 'pugio', meaning dagger; pertaining to the shape of the genal spine.

v.1879 Proetus? or Acidaspis? sp. ind.; Nicholson & Etheridge, p.206, pl.14, fig.15.

1899 Proetus girvanensis (Eth. & Nich.); Peach & Horne, p.538 [List].

1904 Proetus stokesi (Murchison), 1839; Reed, p.79 (pars.).

Holotype. GSE 5775, Pl.8, figs.7a,b, complete specimen; figured Nicholson & Etheridge 1879, pl.14, fig.15; from Wood Burn Formation, Locality 21 (Bargany Pond Burn).

Material, locality and horizon. From type locality: GSE M2633[a] (Pl.8, fig.14) part of cephalon; YH B156 (Pl.8, fig.8), YH B142, cranidia; YH B146 (Pl.8, figs.10a,b), free cheek.

Diagnosis. Cyphoproetus with reduced preglabellar field sagittally. Field of free cheek traversed by tropidium. Cephalic margin not incurved at base of short genal spine. Sculpture as very fine granules except for steep sides of tropidium and anterior part of glabella where coarsely granulated.

Dimensions of holotype. Sagittal length of dorsal shield, 6.0mm; width of thorax, 4.0mm; sagittal length of cephalon, 3.0mm; width of cephalon, 5.0mm; length of pygidium, 1.0mm; width of pygidium, 3.0mm.

Description. Cranidium not quite as wide (tr.) as long (sag.). Glabella approximately as long (sag.) as wide (tr.), rounded anteriorly. 1L oval in outline, approximately $\frac{1}{2}$ length (exsag.) of glabella aligned at 20° from sagittal line, $\frac{1}{4}$ width (tr.) of glabella. 1S running back at about 20°, deepest at its midlength shallowing at either end, anterior limit opposite anterior limit of palpebral lobe. 2S shallow, transverse, 1/5 width (tr.) of glabella opposite anterior limit of palpebral lobe and 1S. 3S $\frac{1}{2}$ width (tr.) of 2S, transverse, shallow, positioned midway between 2S and anterior limit of glabella. Occipital ring slightly wider than glabella, 4 times wider (tr.) than long (sag.). Occipital lobe small but well defined, positioned between adaxial limit of palpebral lobe and abaxial limit of 1L. Occipital furrow narrow, well defined. Anterior border 1/5 length (sag.) of cranidium narrowing laterally, medially almost touching anterior margin of glabella. Anterior border furrow broad. Preglabellar field present laterally as subtriangular area depressed below anterior border and glabella but slightly inflated posteriorly. Anterior branch of facial suture diverging abaxially forwards at 40°-50° from almost opposite 2S, curving adaxially from level with front of glabella crossing anterior border level with lateral extent of glabella. Palpebral lobe 1/3 length (exsag.) of cranidium, straight-edged adaxially, parabolic in outline abaxially, abutting against 1L. Eye not preserved. Posterior branch of facial suture swings rapidly abaxially, from posterior limit of palpebral lobe, so as to be transverse, but most lateral limit of suture unknown. Field of free cheek traversed by tropidium parallel with margin, sloping rapidly down to shallow, wide lateral border furrow, which merges with posterior border furrow. Posterior border transverse. Genal spine blade-like, short, extending backwards as far as fourth thoracic segment. External surface of cephalon without distinct sculpture except on steep sides of tropidium of free cheek where coarsely granulated and for most anterior part of glabella where granulated. Cephalic doublures as wide (tr.) as cephalic border, with well defined terrace ridges subparallel with margin.

Rostral plate and hypostome unknown.

Thorax with at least 10 segments. Axis 1/3 width (tr.) of thorax, gradually tapering backwards. Axial ring approximately 4 times wider (tr.) than long (sag.), shorter (exsag.) laterally than medially. Pleura horizontal and transverse for adaxial ½ but recurving ventrally beyond the fulcrum. Pleural furrow narrow, distinct, dividing pleura into short (exsag.) anterior band and long posterior band both sloping upwards from pleural furrow, dying out beyond fulcrum. Pleura terminating laterally as blunt point.

Pygidium 2 2/3 wider than long. Pygidial axis anteriorly equal in width (tr.) to length (sag.) of pygidium tapering to blunt point. Very weak postaxial ridge. 5? axial rings, delimited by shallow axial ring furrow. Pleural areas with 3? pairs of ribs, not well preserved but seems to reflect appearance of thoracic segments in respect of pleural furrows and bands. External surface of thorax and pygidium without sculpture. Pygidial doublure broad with terrace ridges subparallel to margin.

Discussion. *Cyphoproetus pugionis* sp. nov. closely resembles *C. binodosus* (Whittard, 1938) from the Purple Shales (Telychian) of the Onny River, Shropshire, but the anterior margin of the glabella of the former is more rounded in outline and the anterior border is much longer sagittally than laterally. *C. binodosus* shows only a slight lengthening sagittally. *C. pugionis* also differs in that it has a clearly defined tropidium on the free cheek, a character absent in the Shropshire form, In this feature *pugionis* is similar to a partially exfoliated cephalon from the Hughley Shales (Idwian), Church Stretton, No.2 Borehole (Robury Ring) described by Owens (1973a, p.34, pl.6, fig.5) as *C.* aff. *binodosus*. However, the Girvan form differs in not possessing a preglabellar field sagittally. The presence of a preglabellar field sagittally in both *C. depressus* (Barrande, 1846) from the Wenlock of Czechoslovakia, Germany and Britain, and C. strabismus Owens 1973a, from the Wenlock of the Long Mountain, Powys, separate them from pugionis.

Subfamily TROPIDOCORYPHINAE Přibyl, 1946.

[= Prionopeltiinae Přibyl, 1946; Proetidellinae Hupé, 1953; Decoroproetinae Erben, 1966].

Genus Decoroproetus Přibyl, 1946.

[= Warburgaspis Přibyl, 1946; Proetidella Bancroft, 1949; Ogmocnemis Kielan, 1960].

Type species. Original designation by Přibyl, 1946, p.92; Proetus decorus Barrande 1846, p.64; from Liten Formation (Wenlock, flexilis Zone), Loděnice, Prague district, Czechoslovakia.

Diagnosis and discussion. See Owens (1973a, p.41).

1. Decoroproetus farragatus sp. nov. Pl.8, figs.11-13,15-18,20,21.

Name. Latin 'farrago', meaning mixture; pertaining to the fact that the species shows both Cyphoproetus and Decoroproetus characters.

Holotype. SM A74613, Pl.8, fig.13), internal mould of cranidium; from Newlands Formation, Locality 14 (Newlands Farm).

Material, localities and horizons. From type locality: YH NW432 (Pl.8, figs.11a,b), YH NW427 (Pl.8, figs.12a,b), cranidia; SM A74611 (Pl.8, fig.15), hypostome and two free cheeks; YH NW441,443 (Pl.8, fig.17), YH NW446, YH NW447 (Pl.8, fig.16), 448,507,515, free cheeks; BM In42700,1(Pl.8, figs. 21a,b), In42691, In42697 (Pl.8, fig.20), YH NW328, pygidia. From Woodland Formation, Locality 18: YH WA5, free cheek.

Diagnosis. Glabella only gently convex, anterior margin transverse. 1L subtriangular in outline. 1S well defined. Very poorly defined occipital lobe beneath 1L. No preglabellar field. Anterior border greatly lengthened and flattened with transverse shallow depression at its midlength. Free cheek with posterior border lengthening (exsag.) rapidly towards base of free cheek. Four pairs of pleural ribs with posterior band more pronounced than anterior.

Dimensions of holotype. Sagittal cranidial length, 2.5mm; maximum cranidial width, 2.0mm.

Description. Cranidium 1 1/3 times longer (sag.) than wide (tr.). Glabella, slightly more than ½ length (sag.) of cranidium, as wide as long, tapering weakly forwards, anterior margin transverse. 1L subtriangular in outline, approximately ¼ length (exsag.) of glabella. 1S deep, shallowing at either end. 2S and 3S not seen. Occipital ring 1/5 length (sag.) of cranidium, as wide as glabella. Occipital lobe small, ovate, below lateral limit of 1L. Occipital furrow narrow and shallow, median section transverse. Axial furrow as wide and deep as occipital furrow. No preglabellar field. Anterior border furrow wide and deep medially. Anterior border ¼ length (sag.) of cranidium with transverse depression at midlength, posterior edge virtually transverse. Anterior section of facial suture diverges abaxially forwards at about 25° turning adaxially to cut anterior border. Posterior section of facial suture not preserved. Palpebral lobe 1/3 length (exsag.) of cranidium, semi-elliptical in outline. Only one external surface of cranidium known showing no distinct sculpture. Field of free cheek narrow and gently convex. Eye large and crescentie, eye socle narrow, better defined posteriorly. Lateral border furrow shallow. Lateral border flattened and wide, widens only slightly posteriorly. Posterior border furrow narrow and deeper than, and terminating at, lateral border furrow. Posterior border widens considerably laterally. Genal spine very broad based, as long as the non-spinose part of cheek, with weak median groove dying out before point of spine. No distinctive sculpture seen.

Hypostome known from poorly preserved external mould, with strongly raised convex middle body with poorly defined backwardly directed middle furrow. Anterior border seemingly long (sag.) with shallow anterior border furrow, Lateral and posterior border furrows wide and deep. Lateral border high and narrow; posterior border not preserved. Badly preserved terrace ridges lying exsagittally on middle body.

Thorax unknown.

Pygidium subparabolic in outline, 1 1/3 times wider (tr.) than long (sag.). Axis convex, 1/3 width (tr.) of pygidium anteriorly and approximately $\frac{3}{4}$ of its length (sag.), terminating bluntly. No postaxial ridge present. At least 4 axial rings. 4 pairs of pleural ribs diverging outwards and backwards from axis. Interpleural furrows better defined than pleural furrows. First rib with anterior and posterior bands almost equal. Remaining ribs with posterior band greatly emphasized, posterior slope being steeply inclined (imbricate type of Owens, 1973a, p.5). Pygidial doublure $\frac{1}{4}$ length (sag.) of pygidium, subconcentric with posterior margin. Dorsal surface of pygidium with very fine terrace ridges.

Discussion. The deep 1S furrow defining a distinct 1L lobe and an occipital ring with lateral lobes are features characteristic of *Cyphoproetus*. However, the remainder of the dorsal shield resembles *Decoroproetus* especially in respect of the free cheek and the imbricate outline of the ribs of the pygidium. Overall, *D. farragatus* is very similar to *D. campanulatus* Owens (1973, p.141, figs.5D-K). In both these species the cranidia have the *Cyphoproetus* features mentioned above but the remainder of the dorsal shields are of *Decoroproetus* character. These species link *Cyphoproetus* and *Decoroproetus* and therefore perhaps the two genera should be synonomized. However, more species of this 'linking' variety need to be described to ascertain the relationship between the two genera. For the time being the two species are retained in *Decoroproetus* following Owens' (1973) lead.

2. *Decoroproetus* sp. Pl.8, fig.19.

Material, locality and horizon. From Lower Camregan Grits, Locality 16: LRMC 12 (Pl.8, fig.19), free cheek.

Description. *Decoroproetus* free cheek with typical large eye, wide and flat lateral border merging with narrower posterior border into genal spine with shallow median groove.

Discussion. This is the only Decoroproetus representative from Locality 16.

Genus Astroproetus Begg, 1939

[= Clypoproetus Begg, 1939; Sibiroproetus Přibyl, 1970; ?Enodiproetus Přibyl, 1970].

Type species. Original designation; Proetus (Astroproetus) reedi Begg, 1939, p.375; from Upper Drummuck Group, (Ashgill Series, Rawtheyan Stage), Lady Burn, Girvan, Strathclyde.

Diagnosis and discussion. See Owens (1973a, p.55).

1. Astroproetus scoticus (Reed, 1941) Pl.9, fig.1.

v.1973a Astroproetus scoticus (Reed, 1941); Owens, p.58, pl.11, figs. 5-10 [with full synonomy].

Holotype. By monotypy; HM A1109, internal mould of cranidium; figured Reed 1941, pl.5, fig.3, refigured Owens 1973a, pl.11, fig.7; from Mulloch Hill Formation, Locality 6 (Craigens Quarry).

Material, localities and horizons. This species is represented in the major palaeontological museums of the British Isles and no attempt is made to give a comprehensive list. The specimen figured herein is from Mulloch Hill Formation, Locality 5: YH K5/8 (Pl.9, figs.1a,b), cephalon, hypostome and thorax. This species is also known from Mulloch Hill Formation, Locality 3; and Woodland Formation, Locality 18.

Diagnosis. See Owens (1973a, p.59).

Description and discussion. A description of the hypostome can be added to the description by Owens (1973a, p.59).

Hypostome approximately twice as wide (tr.) as long (sag.), middle body inflated, anterior margin and wings not preserved, posterior margin rounded. Abaxial end of middle furrow approximately ½ way along middle body from posterior, delimiting anteriorly pair of strongly raised maculae. Lateral and posterior borders not well preserved. Terrace ridges on middle body, indistinct posteriorly, but anteriorly diverging outwards and backwards.

Also, free cheek of specimen YH K5/8b (Pl.9, fig.1a) shows 'genal caecae'.

2. Astroproetus interjectus (Reed, 1935)   Not illustrated.

v.1973a Astroproetus interjectus (Reed, 1935); Owens, p.60, pl.11, figs. 13-15; pl.12, fig.1 [with full synonomy].

Holotype. By monotypy: HM A1031, small internal mould of cranidium; figured Reed 1935, pl.3, fig.23, refigured Owens 1973a, pl.11, figs. 14a,b; from Newlands Formation, Locality 14 (Newlands Farm).

Material, locality and horizon. From type locality: BM In21934, figured Reed 1904, pl.11, figs.4,4a, refigured Owens 1973a, pl.12, figs. 1a,b, BM In42699, figured Owens 1973a, pl.11, fig.15, HM A3822, holotype of Proetus subtriangularis Begg 1950, pl.14, fig.6, refigured Owens 1973a, pl.11, figs.13a,b, HM A5022,23, cranidia.

Description and discussion. See Owens (1973a, p.60).

3. Astroproetus pseudolatifrons (Reed, 1904)   Pl.9, figs.2-4.

v.1973a Astroproetus pseudolatifrons (Reed, 1904); Owens, p.60, pl.12, figs.2-5 [with full synonomy].

Lectotype. Designated Owens 1973a, p.60; figured Reed 1904, pl.11, fig.7, refigured Owens 1973a, pl.12, figs.4a,b; BM In21946 , internal mould of cranidium; from Lower Camregan Grits, Locality 19 (Camregan Wood).

Material, locality and horizon. From type locality: BM In21946, paralectotype pygidium on same slab as lectotype, figured Reed 1904, pl. 11, fig.8, refigured Owens 1973a, pl.12, fig.2; GSE JS17833, JS17936, JS17933, JS17938, JS17939 (Pl.9, fig.2), cranidia; BM In21949, figured Owens 1973a, pl.12, fig.5, GSE JS17935 (Pl.9, fig.4), JS17934, free cheeks;

BM In21947, figured Owens 1973a, pl.12, fig.3, GSE JS17940,1,2 (Pl.9, fig.3), JS17943-6, pygidia.

Description. The availability of more specimens has enabled additions to be made to the description of Owens (1973a, p.61). Specimen GSE JS17939 (Pl.9, fig.2) shows clearly lateral glabellar furrows. 1S originating at axial furrow 1/3 length of glabella from occipital furrow, directed backwards and adaxially dying out before reaching occipital furrow. 2S originating at approximately ½ length of glabella, parallel to, but shorter than, 1S. 3S midway between 2S and anterior margin of glabella, parallel with 2S. Lateral border furrow of free cheek as deep and wide as posterior border furrow. Lateral border furrow continuous with median furrow on genal spine. Genal spine as long as non-spinose part of free cheek.

Discussion. The elongated trapezoidal glabella with weak constriction distinguishes A. pseudolatifrons from other Astroproetus species. The arrangement of lateral glabellar furrows is similar to that of A. scoticus but in the latter the furrows appear to extend further across the glabella and 3S is positioned more anteriorly.

Proetid gen. indet. Pl.9, fig.5.

Material, locality and horizon. From Newlands Formation, Locality 14: BM In42687 (Pl.9, figs.5a,b), pygidium.

Description. Pygidium twice as wide as long, semi-elliptical in outline, with narrow border and wide border furrow. Axis reaching posterior border furrow, 1/3 width of pygidium anteriorly tapering posteriorly, terminating bluntly. At least 6 axial rings delimited by shallow axial ring furrows. Axial furrow distinct, reaching posterior border. At least 4 pairs of pleural ribs defined by shallow interpleural furrows. Pleural furrow very faintly defined on external cast, clearer on internal moulds, bisecting rib into 2 bands parallel with interpleural furrow. No distinct sculpture.

Discussion. It is not possible to place this specimen in any described species of proetid. The wide pygidial axis, the shallow furrows, the presence of a narrow border with border furrow, separates the form from any other.

Family BRACHYMETOPIDAE Prantl & Přibyl, 1951.

[*nom. transl.* Hupé, 1955 (*ex* Brachymetopinae Prantl & Přibyl, 1951)]

Diagnosis. See Owens & Thomas (1975, p.809).

Subfamily WARBURGELLINAE Owens, 1973a.

[=Warburgellinae Yolkin, 1974]

Diagnosis and discussion. See Owens & Thomas (1975, p.810).

Genus *Warburgella* Reed, 1931a

[=*Podolites* Balashova, 1968; ?*Waigatchella* Maksimova, 1970]

Type species. Original designation by Reed, 1931a, p.14: *Asaphus Stokesii* Murchison, 1839, p.656; from the Wenlock Limestone (Wenlock Series) of Dudley, West Midlands.

Diagnosis. See Owens (1973a, p.65).

Subgenus *Warburgella* Reed, 1931a.

Type species. As for genus.

Diagnosis. See Owens (1973a, p.66).

1. *Warburgella* (*Warburgella*) *capetos* sp. nov. Pl.9, figs.6-11.

Name. Greek 'kapetos', meaning groove; pertaining to the anterior border furrow of the cranidium.

?1899 *Proetus Stokesi* (Murch.); Peach & Horne, p.550 [List].

Holotype. GSE M1020[e], Pl.9, fig.7, internal mould of cranidium; from Knockgardner Formation, Locality 24.

Material, locality and horizon. There are many representatives of this species in various British palaeontological museums especially I.G.S., Edinburgh and the Hunterian Museum, Glasgow. The author has also collections from the type locality. No attempt is made here to give a comprehensive list of specimens. Material figured herein is as follows. From type locality: GSE M1036[e] (Pl.9, fig.9), cranidium; YH 3K24 (Pl.9, fig.6), YH 1K20 (Pl.9, fig.8), free cheeks; RCK 5 (Pl.9, fig.10), YH 2K22 (Pl.9, fig. 11), pygidia.

Diagnosis. Cranidium only slightly inflated. No transverse preglabellar ridge. Tropidial ridges developed strongly on cephalon. Occipital lobe distinct on internal moulds. Pygidial axis with at least 7 rings; pleural areas with at least 6 pairs of ribs.

Dimensions of holotype. Sagittal cranidial length, 5.0mm; cranidial width, 4.5mm.

Description. Cranidium not greatly convex, slightly wider (tr.) than long (sag.). Glabella moderately convex, slightly wider across 1L lobes than long (sag.), reducing to $\frac{3}{4}$ this width for anterior $\frac{1}{2}$ of length, anterior margin transverse. 1L isolate, oval in outline, with slightly different convexity from rest of glabella. 1S very shallow abaxially opposite anterior limit of palpebral lobe, deepening rapidly backwards but shallowing alittle again just before reaching occipital furrow. 2S opposite anterior limit of palpebral lobe, faintly impressed, obliquely aligned backwards. 3S very close to, and equal in length to, 2S, obliquely aligned anteriorly. Occipital furrow very short (sag.) and transverse. Occipital ring approximately $\frac{1}{4}$ length (sag.) of glabella, length constant for whole width of ring. Occipital lobe small. Preglabellar field as long (sag.) as occipital ring, traversed by tropidium. Anterior border furrow fairly shallow and long (sag.). Anterior border greatly convex, as long (sag.) as preglabellar field. Palpebral lobe with posterior limit opposite occipital furrow, 1/3 length (exsag.) of cranidium, semi-elliptical in outline. Anterior section of facial suture diverges at about 40°-50° from exsagittal line, describing sigmoidal curve. Posterior section of facial suture not preserved. Field of free cheek traversed by tropidium running subparallel with margin. Eye

½ length (exsag.) of non-spinose part of free cheek, visual surface not preserved. Posterior border furrow shallower than lateral border furrow. Posterior border longer (exsag.) than lateral border increasing in length laterally. Genal spine about as long (exsag.) as non-spinose part of free cheek, with deep median groove which shallows posteriorly. Doublure as wide as lateral border with terrace ridges parallel with lateral margin.

Hypostome and thorax unknown.

Pygidium twice as wide (tr.) as long (sag.), not greatly convex, subparabolic in outline. Axis 1/5 width (tr.) of pygidium anteriorly, tapering alittle posteriorly, 4/5 length of pygidium, terminating bluntly; at least 7 axial rings becoming indistinct posteriorly. Postaxial ridge narrow, poorly defined. Pleural field only very gently convex sloping down to narrow border, with 5 or 6 pairs of ribs curving very gently backwards, widening slightly abaxially. Pleural furrows visible only on slopes of borders. Interpleural furrows distinct adaxially, dying out before reaching margin.

Discussion. Most of the specimens referred to this species are internal moulds. In the form of the cranidium it resembles most closely Warburgella (Warburgella) baltica Alberti 1963, from late Llandovery or early Wenlock, Lummelunda, Gotland, Sweden (Lindström 1885, pl.16, fig.13, refigured Owens 1973a, pl.14, figs.3a,b). Both species have an anterior border furrow as long (sag.) as anterior border, but the Girvan form has 1L more obliquely placed and the glabella tapers more rapidly anteriorly.

2. ?Warburgella (Warburgella) sp.   Pl.9, figs.12,13.

Material, localities and horizons. From Lower Camregan Grits, Locality 16: LRMC 11 (Pl.9, figs.12a-c), cephalon and part of thorax. From Wood Burn Formation, Locality 21: YH B142 (Pl.9, fig.13), cranidium.

Description. Cephalon only slightly wider (tr.) than long (sag.), greatly vaulted especially medially. Anterior and lateral borders only slightly inflated and equal for whole length with wide, shallow anterior and lateral border furrows. Glabella 1 1/3 times longer (sag.) than wide (tr.) subparallel-sided, rounded anteriorly, greatly inflated, but sloping rapidly downwards anteriorly to preglabellar furrow. 1L elongate, 3 times longer (exsag.) than wide (tr.), 1/5 length of cranidium. 1S well defined, shallow medially, deeper at either end where meets axial furrow and occipital furrow; anterior end opposite midlength of palpebral lobe. 2S not distinct. Occipital ring as wide (tr.) as base of glabella, approximately 3 times wider (tr.) than long (sag.). Occipital lobes well defined, subtriangular in outline, equal in width (tr.) to 1L, $\frac{1}{3}$ length (exsag.) of occipital ring. Occipital furrow shallow, narrow and transverse. Preglabellar field $\frac{1}{8}$ length (sag.) of cephalon slightly convex. Palpebral lobe long, 2/5 length (exsag.) of cephalon, subparabolic in outline. Eye not preserved. Anterior section of facial suture diverges forwards from infront of palpebral lobe at approximately 20°, crossing anterior border slightly further laterally than abaxial limit of palpebral lobe. Posterior course of facial suture not preserved. Field of free cheek of same convexity as preglabellar field. Posterior border wider and posterior border furrow narrower than lateral border and furrow. Length of genal spine unknown. No sculpture of cephalon visible.

Only 3 thoracic segments poorly preserved, axis 1/3 width of thorax.

Discussion. This form strongly resembles *W.* (*Warburgella*) *baltica* Alberti, 1963, in the wide anterior border furrow but the preglabellar field is longer (sag.) than the anterior border. It resembles *Harpidella* sp. also found at Locality 16 but it does not possess the wide fixed cheek or rounded outline of the anterior margin of the glabella characteristic of *Harpidella*. It does not belong to *Otarion* which has a small eye and a very long preglabellar field.

Family AULACOPLEURIDAE Angelin, 1854

[= Cyphaspidae Salter, 1864; Otarionidae Richter & Richter, 1926]

Discussion. The writer agrees with Bergström (1973, p.42) and Fortey & Owens (1975, p.230) that the Otarionidae and Aulacopleuridae are synonymous. The differences between Aulacopleura and Otarion are that the former has a larger number of thoracic segments, lacks the thoracic axial spine, and possesses a well developed eye ridge. These differences do not constitute their separation at family level. For further discussion see Thomas (1975, p.59).

Subfamily OTARIONINAE Richter & Richter, 1926

[nom transl. Přibyl, 1947 (ex Otarionidae Richter & Richter, 1926); = Cyphaspidinae Přibyl, 1947]

Diagnosis and discussion. See Thomas (1975, p.60).

Genus Harpidella McCoy, 1849

[=Goniopleura Hawle & Corda, 1847 (non Westwood, 1832); Maurotarion Alberti, 1969].

Type species. By monotypy; Harpes? megalops McCoy, 1846, p.54, pl.4, fig.5; from presumed late Llandovery, Cong district, County Galway, Eire.

Other species. H. aitholix Thomas, 1975; H. christyi (Hall, 1864); H. elegantula Lovén, 1845; H. instita (Whittington & Campbell, 1967); H. intermedia (Weller, 1907); H. maura Alberti, 1967; H. neptis Alberti, 1967; H. novella (Barrande, 1852); H. plauta (Whittington & Campbell, 1967); H? ambigua Alberti, 1967; H. giradensis (Schumard, 1855); H? pygmaea (Salter, 1853); H. megalops [?] assigned Temple (1969, pl.5, figs.1-5,7-13,15-19,21, 22,?20); H. cf. megalops of Cocks & Price, 1975.

Diagnosis and discussion. See Thomas (1975, p.70).

1. Harpidella newlandensis (Begg, 1950)   Pl.9, figs.14-18.

1851 Harpidella megalops M'Coy; Sedgwick & McCoy, p.368 (pars) [List].

1853 Cyphaspis megalops McCoy; Salter, No.5, p.5 (pars).

1857 Cyphaspis megalops M'Coy; Thomson, p.209 (pars) [List].

1867 Cyphaspis megalops M'Coy; Bigsby, p.47 (pars) /List7.

1873 Cyphaspis megalops McCoy; Salter, p.77 /List7.

1877 Cyphaspis megalops M'Coy, 1846; Woodward, p.34 (pars) /List7.

1879 Cyphaspis megalops M'Coy; Nicholson & Etheridge, p.140.

1891 Cyphaspis megalops (McCoy); Woods, p.144 (pars) /List7.

1904 Cyphaspis megalops (M'Coy), 1846; Reed, p.82.

1906 Cyphaspis megalops (M'Coy); Reed, p.167.

1931a Cyphaspis megalops (McCoy); Reed, p.15.

v*1950 Cyphoproetus newlandensis Begg, p.287, pl.14, fig.7.

1973a Otarion newlandensis (Begg, 1950); Owens, p.79.

Holotype. HM A3824, Pl.9, figs.14a,b, internal mould of cranidium; figured Begg 1950, pl.14, fig.7; from Newlands Formation, Locality 14.

Material, localities and horizons. From type locality: HM A10674, BM In43154 (Pl.9, figs.16a,b), BM It9108, BM It9094, It9100, YH NW425 (Pl.9, fig.17), YH NW436,434,626,618(Pl.9, figs.18a,b), SM A4873 (Pl.9, fig.15) mentioned McCoy 1851, p.368, mentioned Salter 1873, p.77, recorded Nicholson & Etheridge 1878, p.140, Woods 1891, p.144, Reed 1904, p.83, cranidia. From Woodland Formation, Locality 18: YH WG12, cranidium. From Mulloch Hill Formation, Locality 10: YH G53/1, G52,12 and 2 specimens from IRMC collection, cranidia.

Diagnosis. Harpidella species with anterior border as long sagittally as exsagittally, slightly upturned. Field of fixed cheek narrow. Cranidial sculpture of coarse granules confined to posterior part of glabella.

Dimensions of holotype. Sagittal cranidial length, 3.0mm; maximum cranidial width not known.

Description. Cranidium $1\frac{3}{4}$ times wider (tr.) than long (sag.). Glabella about $\frac{1}{2}$ length of cranidium, slightly convex, as wide as long posteriorly, tapering slightly forwards to 2/3 posterior width, bluntly rounded anteriorly. 1L 2/5 glabella length (sag.), triangular in outline, 1/5 width of glabella posteriorly. 1S deep, isolating 1L. 2S not preserved. Occipital ring 1/10 cranidial length (sag.), convex (sag. and tr.) with median granule. Occipital furrow shallow and wider than 1S. Axial furrow deeper and wider than 1S but narrower than occipital furrow. Preglabellar furrow as deep and as wide as 1S. Preglabellar field slightly convex approximately 1/6 cranidial length (sag.) lengthening abaxially, sloping gently downwards from preglabellar furrow. Anterior border furrow wide and shallow; anterior border convex and upturned, decreasing in length (exsag.) laterally. Field of fixed cheek very narrow (tr.) especially posteriorly. Anterior section of facial suture diverges forwards at 30°, from exsagittal line, then recurves to cross anterior border. Palpebral lobe approximately $\frac{1}{4}$ cranidial length, as wide as long, extending from midway between 1S and preglabellar furrow to midlength of 1L. Eye ridge not preserved. Posterior branch of facial suture parallel with posterior margin cutting sharply backwards at lateral extent. Posterior border not preserved. Surface sculpture difficult to discern because of the smallness of the specimens and the preservation; however occasional specimens show coarse granules on the posterior parts of the glabella and on the occipital ring.

Discussion. Only the cranidium of this species is known; they are all small, the largest being 4mm in length (sag.). The Girvan form differs from the majority of other species of *Harpidella* in that the anterior border of the cranidium is of almost constant length. Another small species of this genus is from the Keisley Limestone, Westmorland, assigned by Temple (1969, p.221, pl.5, figs.1-5,7-13,15-19,21,22,?20) to *Otarion megalops*. However, the latter form has a more rounded anterior margin to the glabella which tapers more anteriorly, and the fixed cheek area is wider (tr.).

Otarion cf. *megalops* Cocks & Price (1975, pl.82, figs.3-8) from the St. Martin's Cemetery horizon, Haverford Mudstone Formation (Hirnantian), Haverfordwest, Dyfed, is also small and closely resembles *H. newlandensis*. From internal moulds they would appear to be identical but because external casts are not well known for either of these forms the Haverfordwest form will be termed *Harpidella* aff. *H. newlandensis*.

The Girvan form differs from H. elegantula (Lovén, 1845) of Whittard (1938, p.99, pl.3, fig.6) from the Pentamerus Beds (Fronian) of Shropshire, as the latter has a relatively longer (sag.) anterior border of the cranidium but shorter preglabellar field.

H. newlandensis resembles H. novella (Barrande, 1852) which has a more strongly tapering forward glabella and a longer (sag.) occipital furrow. It agrees with the Girvan form in the blunt anterior margin of the glabella and the short (sag.) anterior border. H. newlandensis is distinct from the type of the genus, H. megalops, as the Cong cranidia are more inflated with the preglabellar field sloping steeply down to the anterior border, the fixed cheek is very wide, and the anterior margin of the glabella is rounded.

2. Harpidella cf. H. newlandensis (Begg, 1950)   Pl.10, figs.1-5.

Material, localities and horizons. From Lower Camregan Grits, Locality 19: BM In21954 (Pl.10, figs.4a-c) complete specimen. From Lower Camregan Grits, Locality 16: HM A9117/2 (Pl.10, fig.2), HM A9150 (Pl.10, fig.5), HM A9152/1a (Pl.10, figs.3a,b), HM A9152/1b, HM A9113/1a,1b, HM A91-13/2, LRMC 13, GSE EG8226 (Pl.10, fig.1), cranidia.

Description. Harpidella cranidium similar to H. newlandensis except for differences outlined below. Glabella, on the whole, narrowing more gently anteriorly. 1L somewhat depressed and 1/3 glabella length (sag.). Palpebral lobe narrower (tr.) with shallow palpebral furrow. Field of fixed cheek wider. Cranidium coarsely granulated (see specimen GSE EG8226, Pl.10, fig.1).

Free cheek with slightly convex lateral border; lateral border furrow shallow. Posterior border slightly narrower than lateral border; posterior border furrow same width and depth as lateral furrow - both furrows merging backwards to produce distinct median furrow in genal spine. Genal spine about ½ length of rest of free cheek. Eye large, ½ length of free cheek excluding genal spine. No surface sculpture discernable. Cephalic doublure as wide as anterior and lateral borders.

Rostral plate and hypostome unknown.

Thorax with ?11 segments; no axial spine developed. Axis 1/3 thoracic width (tr.). No external surface details known. Pleura parallel-sided, reflected downwards beyond fulcrum.

Pygidium not well preserved, approximately 1/10 length (sag.) of whole shield, 3 times wider than long. Axis constitutes 2/3 length (sag.) of pygidium; 2 axial rings visible but no other features distinguishable.

Discussion. The poor preservation of the specimens and their smallness does not permit this Girvan form to be compared satisfactorily with other members of the genus, except that, as with H. newlandensis, it resembles most closely the Harpidella form from the Haverfordwest Mudstone Formation (Hirnantian) of Haverfordwest, Dyfed.

Family HARPETIDAE Hawle & Corda, 1847

Discussion. For usage and spelling of this name see Bull. zool. Nom., 1971, **28**, pp.56-8; 1972, **29**, pp.2,108; 1973, **30**, p.3.

Genus Scotoharpes Lamont, 1948

[=Selenoharpes Whittington, 1950 and Aristoharpes Whittington, 1950]

Type species. Original designation; Eoharpes domina Lamont 1947, p.289; from Plectodonta aff. canastonensis beds (late Llandovery), Wether Law Linn, North Esk Inlier, Pentland Hills, Scotland.

Diagnosis, other species and discussion. See Norford (1973, p.9).

Scotoharpes volsellatus sp. nov. Pl.10, figs.6,7.

Name. Latin 'volsella', meaning tweezers; pertaining to the long prolongations of the cephalon.

1899 Harpes sp.; Peach & Horne, p.538 [List].

v.1903 Harpes sp. ind.; Reed, p.9, pl.2, fig.14.

1947 Harpes sp. ind.; Lamont, p.290.

v.1950 Aristoharpes sp. ind.; Whittington, p.48, pl.7, fig.13.

1973 Scotoharpes sp.; Norford, p.10.

Holotype. BM In20759, Pl.10, fig.7, incomplete external mould of cephalon; figured Reed 1903, pl.2, fig.14, refigured Whittington 1950, pl.7, fig.13; from Wood Burn Formation, Locality 21 (Bargany Pond Burn).

Other material. From type locality: YH B55 (Pl.10, figs.6a-c), enrolled specimen.

Diagnosis. Scotoharpes species with prolongations longer than cephalon and curving adaxially. Anterior margin of brim virtually transverse. Non-brim part of cephalon only moderately convex. Genal caecae present on cheek but indistinct on brim. Brim with many small pits. Eye very close to anterior part of glabella. No evidence of eye ridge.

Dimensions of holotype. Total cephalic length with prolongations, 20.0mm; cephalic width, 17.5mm.

Description. Cephalon moderately convex, suboval in outline, 1 1/3 times longer (sag.) than width (tr.) taken through position of occipital ring, almost transverse anteriorly. Prolongations greater than sagittal length of cephalon, crescentic in outline terminating in adaxially pointing tips. Glabella 1/6 width (tr.) and 1/3 cephalic length (sag.), parallel-sided, rounded anteriorly, posterior limit not preserved, strongly convex. 1L triangular in outline. Occipital ring preserved only laterally. Preglabellar field 1/8 axial length of cephalon sloping rapidly anteriorly, and passing laterally into convex cheek lobes. Cheek lobes rapidly sloping down to inner margin of upper lamella but sloping very gently to axial furrow. Eye mound circular in outline 1/18 width of cephalon situated opposite and very close to anterior ½ of glabellar lobe. No eye ridge discernable. Ala semicircular in outline, depressed, flat, approximately twice as long (exsag.) as eye and 2/3 this length in width (tr.). Posterior border transverse and straight for ¾ of its width (tr.) but laterally running obliquely backwards to prolongation. Glabella sculpture not preserved, but that of cheek lobe finely punctuated and with faint radiating caecae. Course of ventral girder traced dorsally by change in slope. Brim, anteriorly 1/3 length (sag.) of cephalon, narrowing only alittle laterally, slightly concave. Marginal band very narrow, convex, raised above surface of brim. Brim with fine punctation and granulation, coarser on inner margin of fringe.

Hypostome unknown.

Thorax imperfectly known, but with at least 11 segments. Axis greatly convex, approximately $\frac{1}{4}$ width of segment. Pleura transverse and straight, lateral limit unknown. Pleural furrow broad, straight and shallow on internal mould, external cast with very shallow pleural furrow. Surface sculpture not preserved.

Pygidium unknown.

Discussion. *Scotoharpes volsellatus* differs from other members of the genus in having very long prolongations, the eye placed close to the glabella, no eye ridge, and very indistinct or no caecae on the brim. It most closely resembles *S. domina* (Lamont, 1947) in this last character but differs from that species in that the anterior margin of the brim is transverse, the eye is further forward and there is no eye ridge present.

Family CHEIRURIDAE Hawle & Corda, 1847

[*nom. correct* Salter, 1864 (*ex* Chirurides Hawle & Corda, 1847) = Chiruridae Angelin, 1854; = Ceraurídae Miller, 1889]

Subfamily CHEIRURINAE Hawle & Corda, 1847

[*nom. transl.* Raymond, 1913 (*ex* Chirurides Hawle & Corda, 1847]

Genus *Hadromeros* Lane, 1971

Type species. Original designation; *Cheirurus keisleyensis* Reed, 1896, p.417, pl.20, figs.7-9; from the Keisley Limestone (Ashgill), Keisley, Cumbria.

Diagnosis and discussion. See Lane (1971, p.24).

Hadromeros elongatus (Reed, 1931a)   Pl.10, figs.8-12,14-16.

v.1971 Hadromeros elongatus (Reed, 1931a); Lane, p.28, pl.5, figs.1-14, 16,17 [with full synonomy].

v.1971 Hadromeros cf. H. elongatus (Reed, 1931a); Lane, p.29, pl.5, fig. 15.

v.1975 Hadromeros elongatus (Reed, 1931); Temple, p.154, pl.27, figs.5, 6,8.

Lectotype. Selected Lane 1971, p.28; figured Reed 1931a, pl.4, fig.7, refigured Lane 1971, pl.5, fig.4; HM A1074, external mould of pygidium; from Newlands Formation, Locality 14 (Newlands Farm).

Paralectotypes. From type locality: HM A1072, figured Reed 1931a, pl.4, figs.5,5a, refigured Lane 1971, pl.5, fig.9, HM A1073, figured Reed 1931a, pl.4, fig.6, refigured Lane 1971, pl.5, fig.2, cranidia; HM A1075, figured Reed 1931a, pl.5, fig.4, refigured Lane 1971, pl.5, fig.8, hypostome.

Material, localities and horizons. The major palaeontological museums of the British Isles have representatives of this species within their collections, hence no attempt is made to give a comprehensive list of material, Details of specimens figured herein are given below. From type locality: YH NW449 (Pl.10, fig.8), hypostome; YH N659 (Pl.10, fig.9), free cheek; YH NW103 (Pl.10, fig.11), YH NW104 (Pl.10, fig.16), cranidia. From Mulloch Hill Formation, Locality 10: YH G42 (Pl.10, fig.12), cranidium. From Woodland Formation, Locality 18: BM In44467 (Pl.10, fig.15), cranidium; BM In44517 (Pl.10, fig.10), hypostome; BM In22818 (Pl.10, fig.14), pygidium. The species is also found at Newlands Formation, Locality 11. Outside the Girvan area the species can be found at the Priory Mill Railway cutting, Haverford Mudstone formation (Rhuddanian), Haverfordwest, Dyfed.

Diagnosis. See Lane (1971, p.28).

Description. There is little to add to that of Lane (1971, p.28) but the granules on the anterior part of the glabella decrease in size and increase in number anteriorly. Also the hypostome has few large and many fine granules, see specimen YH NW449 (Pl.10, fig.8).

Discussion. Lane (1971, p.29) considered it wise to separate a solitary pygidium from Locality 18 (Woodland Point) (BM In23400, figured Lane 1971, pl.5, fig.15) from the species with which it was compared, because of the confusion in the age of Woodland Point at that time and of the poor preservation of the specimen. Subsequent finds of more material from Woodland Point shows that there is no difference between this and the Newlands form. A cranidium with its disarticulated thorax has also been found at Locality 10 (Gully) (YH G42) which can be assigned to *H. elongatus*. This would indicate that the time range for *elongatus* extends from at least mid-*cyphus* to lower-*gregarius* Zone. The specimens from the early Llandovery of the Haverfordwest area (Temple 1975, p.154, pl.27, figs.5,6,8) although distorted do not seem to differ from those from Girvan. However, *Cheirurus* sp. Temple (1970, p.65, pl.19, figs.11,12) assigned by Temple (1975, p.155) to *H. elongatus* is considered here to be too badly preserved to place in a species.

Genus *Proromma* Lane 1971

Type species. Original designation; *Proromma bregmops* Lane 1971, p.38, pl.7, figs.5-13; text-fig.7; from Skelgill Beds (early Llandovery), Crummack Dale, near Austwick, North Yorkshire.

Diagnosis. See Lane (1971, p.38) except that proximal extent of 1S reaches or almost reaches occipital furrow.

Proromma sp. Pl.10, figs.13,17, Pl.11, figs.1,2; Text-fig.22.

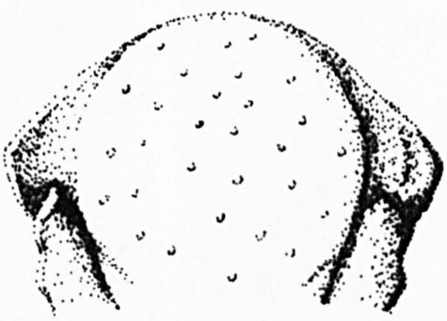
v.1971 *Proromma* sp.A.; Lane, p.40, pl.7, fig.18.

Material, localities and horizons. From Wood Burn Formation, Locality 21: GSE M3001[a] (Pl.10, fig.17), GSE M2641[a], cephala and thoracic segments; GSE M3006[a] (Pl.10, fig.13), GSE M2679[a] (Pl.11, fig.1), cranidia; BM In23421 (Pl.11, fig.2) 5 thoracic segments; YH B130, YH B88 hypostomes. From Wood Burn Formation, Locality 20: YH FW23,25, hypostomes. From ?Lauchlan Formation, Locality 23: BM In23418, figured Lane 1971, pl.7, fig.

18, cranidium. From ?Maxwellston Mudstones, locality unknown: BM In23422,3 cranidia.

Description. See Lane (1971, p.40) with the following additions. Glabella convex, widening forwards to its greatest transverse width across frontal lobe which is slightly less than $\frac{1}{2}$ as great again as estimated width (tr.) of occipital ring. 1S reaches, or almost reaches, occipital furrow. 3S with tendancy to curve anteriorly. Occipital ring convex (sag. and tr.), twice as long (sag.) medially than laterally. Occipital furrow as deep and wide as glabellar furrow.

Hypostome only anterior portion known in detail. Large, gently convex middle body, tapering posteriorly, virtually vertical-sided. Very short (sag.) anterior border lengthening laterally into anterior wings. Lateral border flattened proximally. Lateral border furrow shallow and wide. Surface of middle body with scattered, irregularly-sized, granules. Borders with no distinct sculpture.(See Text-fig.22).



TEXT-FIG.22. Reconstruction of anterior part of hypostome of Proromma sp., based on specimens YH B130 and YH B88, c x5.

Thoracic segments characteristic of members of Cheirurinae.

Pygidium unknown.

Discussion. Since Lane (1971, p.40) described and figured this form new specimens have become available. The majority are from Locality 21 (Bargany Pond Burn). The specimen BM In 23423, a cranidium referred to by

Lane (1971, p.40) and specimen BM In23422 are registered as being collected from Bargany Pond Burn. However, the matrix of these two specimens of a purple-red colouration is unlike the grey-green of the Wood Burn Formation at Bargany Pond Burn. It would seem likely that these specimens are from the purple-coloured Maxwellston Mudstones, which could have been collected alittle further down stream from the 'true' Bargany Pond Burn locality.

Subfamily DEIPHONINAE Raymond, 1913

Genus Deiphon Barrande, 1850

Type species. Original designation; Deiphon Forbesi Barrande 1850, p.6, two unnumbered text-figs.; from the Wenlock of Czechoslovakia.

Other species and diagnosis. See Lane (1971, p.59).

Deiphon sp. Pl.11, figs.3-8.

1906 Deiphon Forbesi, Barrande 1850; Reed, p.150.

1931a Deiphon forbesi, Barrande; Reed, p.23.

1934 Deiphon forbesi dikella Whittard, p.880.

Material, localities and horizons. From Woodland Formation, Locality 18: BM In44468 (Pl.11, figs.3a-c), cephalon. From Mulloch Hill Formation, Mulloch Hill (Localities 8 or 9): BM In23518 (Pl.11, figs.4a-c) cranidium. From Mulloch Hill Formation, Locality 10: YH G57 (Pl.11, fig.5) cephalon. From Newlands Formation, Locality 14: YH NW315 (Pl.11, fig.6), HM A847, cranidia; BM In42704 (Pl.11, figs.7a,b), HM A9058, YH NW584 (Pl.11, figs.8a,b) hypostomes.

Description. Glabella infront of 1S subspherical, furrows absent, approximately as wide (tr.) as long (sag.). 1L small and depressed. Occipital ring raised above 1L but below remainder of glabella. 1S almost transverse. Axial furrow not well preserved but distinct posteriorly. Preglabellar furrow not preserved. Posterior band-like part of fixed cheek aligned obliquely forward, merging into spinose part of fixed cheek. Spinose cheek stout, curving outwards then backwards. Spines not complete but at least 1½ times longer than greatest width (tr.) of glabella. All surfaces except for furrow with coarse granulation. Internal mould without sculpture. Eye not preserved.

Hypostome, subrectangular in outline, slightly wider (tr.) than long (sag.). Middle body subcircular in outline, narrowing slightly posteriorly, greatly convex anteriorly decreasing in height rapidly posteriorly. Macula very small, subcircular in outline (seen only on internal mould of BM In42704, Pl.11, figs.7a,b) positioned approximately 1/3 sagittal length from posterior margin just posterior to very faintly impressed middle furrow. Anterior border short (sag.) lengthening laterally into anterior wing which turns downwards and backwards. Posterior wing small projection from lateral border positioned opposite midlength of middle body. Lateral border furrow wide and shallow. Lateral border narrow anteriorly, widening posteriorly to merge with wide posterior border. Posterolateral corner swept outwards. Surface sculpture not well defined but probably low large granules.

Thorax and pygidium unknown.

Discussion. This form is not sufficiently well known to place it in any existing Deiphon species. The poor preservation of the specimens makes it difficult to compare them with other species. However, the narrow base of the cheek spines and the more granulose sculpture separate it from D. barrandei Whittard, 1934 and the length of the cheek spines are relatively longer than those of D. dikella Whittard, 1934. The granulation of the surface appears to be coarser than any other Deiphon species.

Subfamily ACANTHOPARYPHINAE Whittington & Evitt, 1954.

Genus Youngia Lindström, 1885.

Type species. Subsequently designated by Vogdes, 1917; Cheirurus trispinosus Young 1868, p.169, pl.1, figs.4-6; from Wood Burn Formation, Locality 22 (Penkill), Girvan, Strathclyde, Scotland.

Other species and diagnosis. See Lane (1971, p.69). Two pygidia described by Perry & Chatterton (1977, p.297, pl.3, figs.18,19) from the Baille-Hamilton Island are associated with Youngia and are the first Youngia pygidia to be described. In form the pygidia are close to Acanthoparypha Whittington & Evitt, 1954 and therefore confirm the inclusion of Youngia in the subfamily Acanthoparyphinae as postulated by Whittington & Evitt, 1954 and Lane, 1971.

1. Youngia trispinosa (Young, 1868) Pl.11, figs.9,10.

v.1971 Youngia trispinosa (Young, 1868); Lane, p.69, pl.16, figs.1-4, 7-9,11,13 [with full synonomy].

Lectotype. Selected Lane 1971 p.69; figured Young 1868, pl.1, fig.4, refigured Lane 1971, pl.16, figs.1a,b; HM A52/1, cranidium; from Wood Burn Formation, Locality 22 (Penkill).

Material, localities and horizons. This species is well represented in major British palaeontological museums. Details of figured material is as follows. From type locality: BM In23491, figured Nicholson & Etheridge 1878, pl.7, fig.10, refigured Lane 1971, pl.16, fig.4, BM In23492, figured Nicholson & Etheridge 1878, pl.7, fig.11, BM In23494, figured Nicholson & Etheridge 1878, pl.7, figs.13,13a, BM In23495, figured Lane 1971, pl.16, figs.2a,b, BM In23496, figured Nicholson & Etheridge 1878, pl.7, figs. 14-16, refigured Lane 1971, pl.16, fig.7 non figs.3a,b, BM In23498, figured Reed 1906, pl.19, fig.8, refigured Lane 1971, pl.16, figs.13a,b, BM In23500, figured Reed 1906, pl.19, fig.10, refigured Lane 1971, pl.16, fig.9, HM A52/2, figured Lane 1971, pl.16, figs3a,b, cranidia; BM In23499, figured Reed 1906, pl.19, fig.9, refigured Lane 1971, pl.16, figs.11a,b, glabella; BM In23493 (Pl.11, fig.10), figured Nicholson & Etheridge 1878, pl.7, fig. 12 non Lane 1971, pl.16, figs.3a,b, free cheek; BM In23502, figured Reed 1906, pl.19, fig.11, refigured Lane 1971, pl.16, fig.8, thoracic segment. From Wood Burn Formation, Locality 20: YH PW29 (Pl.11,fig.9), cranidium.

Diagnosis and Description. See Lane (1971, p.69).

2. Youngia aff. Y. trispinosa (Young, 1868) Pl.11, fig.11.

v.1971 Youngia aff. Y. trispinosa (Young, 1868); Lane, p.70, pl.16, figs. 10a,b.

Material, locality and horizon. From Newlands Formation, Locality 14: HM A1111, figured Lane 1971, pl.16, figs.10a,b, HM A2992, (Pl.11, figs. 11a,b), cranidia.

Description and discussion. See Lane (1971, p.70).

Family ENCRINURIDAE Angelin, 1854

Subfamily ENCRINURINAE Angelin, 1854

Diagnosis. See Evitt & Tripp (1977, p.121).

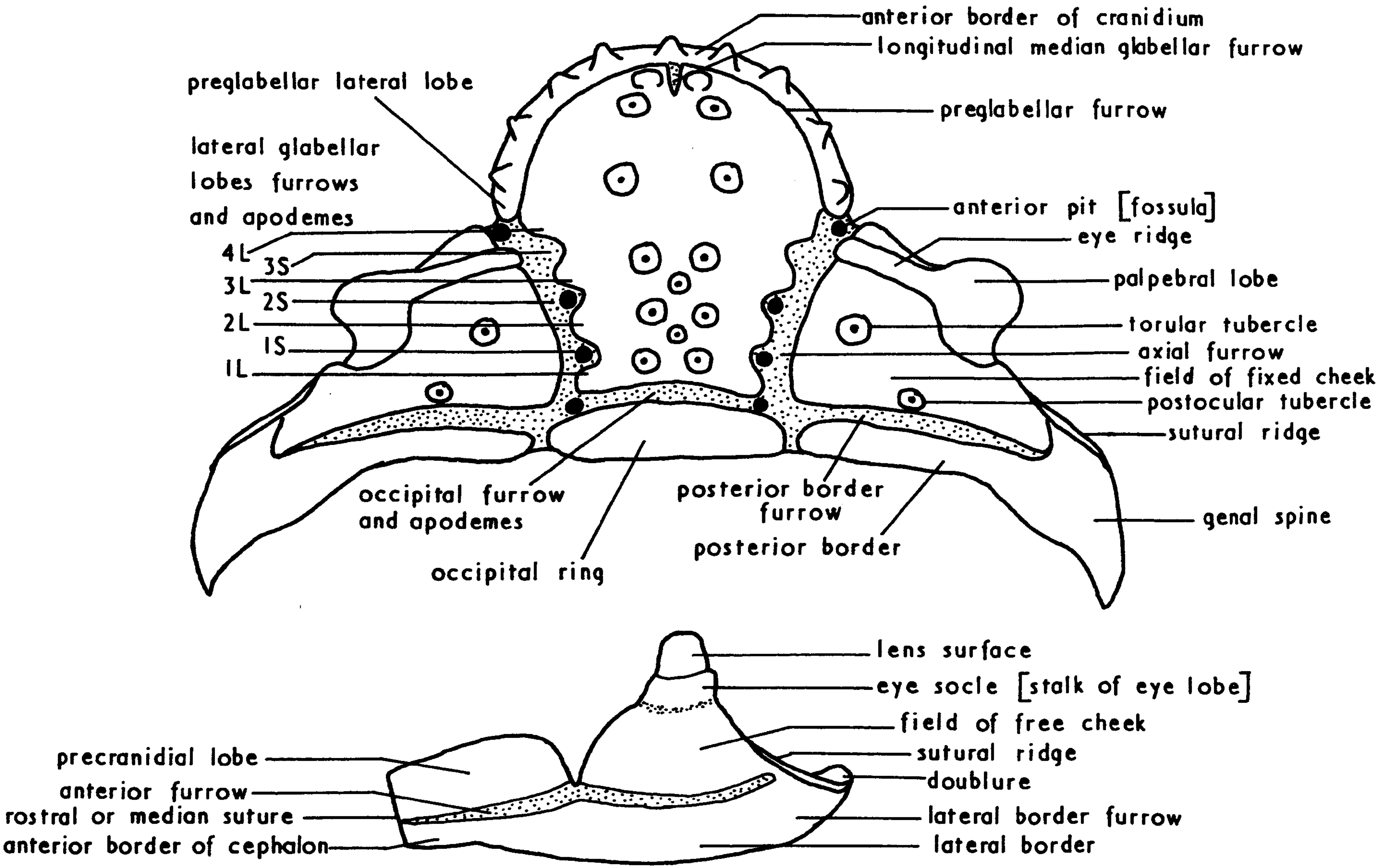
Genus Encrinurus Emmrich, 1844

Type species. Subsequently designated by I.C.Z.N. 1959, Opinion 537,p.43; Entomostracites punctatus Wahlenberg, 1818, p.32, pl.2, fig.1*; from the Wenlock (?Hogklint Group) of Gotland.

Discussion. Species referred to Encrinurus are many and morphologically diverse, ranging in age from middle Ordovician to Silurian. Reed (1928) and Tripp (1957a, 1962a) have recognised morphological groups characterized by certain species within the genus eg. E. variolaris (Brongniart) of Reed, and E. punctatus group and E. multisegmentatus group of Tripp. As with most classifications however the extreme end members of the species groups are difficult to define. A detailed numerical taxonomic study at present in progress by Temple and Tripp of the species shows that there is an almost complete range of variation throughout the genus, especially among the Silurian species.

The nomenclature used is essentially that proposed by Evitt & Tripp (1977, p.112, text-fig.1), herein reproduced (Text-fig.23), with the following changes. The division of the glabella into lateral lobes 1L to 3L is extended to include the most anterior swelling or lobe, also overhanging the

TEXT-FIG.23. Terminology applied to parts of the encrinurine cephalon. Redrawn from Evitt & Tripp (1977, text-fig.1).


anterior border of cranidium
longitudinal median glabellar furrow
preglabellar lateral lobe
preglabellar furrow
lateral glabellar
lobes furrows
and apodemes
4L
3S
3L
2S
2L
1S
1L
anterior pit [fossula]
eye ridge
palpebral lobe
torular tubercle
axial furrow
field of fixed cheek
postocular tubercle
sutural ridge
genal spine
occipital furrow
and apodemes
occipital ring
posterior border
furrow
posterior border
lens surface
eye socle [stalk of eye lobe]
field of free cheek
sutural ridge
doublure
lateral border furrow
lateral border
precranidial lobe
anterior furrow
rostral or median suture
anterior border of cephalon

axial furrow, just posterior to the preglabellar furrow. There seems to be no morphological reason why this lobe should not be a 'true' glabellar lobe and be labelled as such. Here it will be termed 4L. The swelling at the lateral extent of the anterior border of the cranidium is large enough, usually the same size as the lateral glabellar lobes, to be considered not merely as another tubercle on the anterior border. It will here be termed the preglabellar lateral lobe and will be abbreviated to PL. Its relationship to the lateral glabellar lobes is unknown. The term 'eye socle' (Shaw & Ormiston, 1964) is preferred to 'stalk of eye lobe', and 'anterior pit' for 'fossula'. The term 'rhyncos' (Evitt & Tripp, 1977, p.114) is adopted here to describe the swollen anteromedian longitudinal lobe on the middle body of the hypostome of most encrinurid genera. The term mucro (Salter, 1853, Dec.7, pl.4, p.6) is used to describe the unfurrowed tapering posterior extension of the pygidium characteristic of some species of <u>Encrinurus</u>. The large swellings of the cuticle on the cephala of encrinurines have usually been termed tubercles. Miller (1976, p.353) prefers the term dome to describe cuticle structures in which the external and internal surfaces are raised together (Miller <u>Ibid</u>., text-fig.2e-h). However, with reference to encrinurines, although it is obvious that some of the swellings could be termed domes (eg. those usually included in the tubercle formula of the glabella) it is not always possible to know which other protruberances seen on the external surface also have a swelling on the internal mould, this is especially so with the less elevated swellings on external surfaces (cf. Miller, <u>Ibid</u>., text-fig.g and i). To refer to them all as domes may be misleading. Hence, the present author prefers to retain the term tubercle for all large protruberances of the encrinurines, which in turn may be granulated.

The notation employed for the tubercle positions on the glabella is that of Tripp (1957, 1962), but excludes the lateral glabellar lobes which overhang the axial furrow.

Nicholson & Etheridge (1878) and Reed (1906) recorded encrinurines from the Silurian of Girvan as <u>Encrinurus</u> <u>punctatus</u> var <u>calcareus</u> and var arenaceus. Reed (1931, p.19) separated off Encrinurus mullochensis on the basis of pygidial features. Since, these Girvan encrinurines have received attention only from Whittard (1938, p.122) and Rosenstein (1941, p.65). The present author has been able to recognize 6 forms definitely attributable to Encrinurus. A seventh form is doubtfully referred to this genus.

1. Encrinurus mullochensis Reed, 1931 Pl.11, fig.12, Pl.12, figs.1-20.

v.1878 Encrinurus punctatus Brünnich var arenaceus Salter; Nicholson & Etheridge, p.109, pl.8, figs.1-3.

1882 Encrinurus variolaris Brongn.; Lapworth, p.648 [List].

1899 Encrinurus punctatus (Brünn); Peach & Horne, p.536 [List].

1899 Encrinurus punctatus var. arenaceus (Salt); Ibid., p.536 [List].

1906 Encrinurus punctatus var. calcareus; Reed, p.120 (pars).

non1931a Encrinurus mullochensis nom. prop.; Reed, p.19 [=Encrinurus squarrosus sp. nov.].

non1938 Encrinurus mullochensis Reed 1931; Whittard, p.122, pl.5, figs. 1-5 [=Encrinurus sp. nov.].

non1941 E. mullochensis Reed 1931; Rosenstein, p.65 [=Encrinurus sp. nov.]

Lectotype. BM In23210, Pl.12, figs.1a-d, internal mould of complete dorsal shield, figured Nicholson & Etheridge 1878, pl.8, fig.2; from Wood Burn Formation, Locality 22 (Penkill).

Paralectotypes. From type locality: BM In23205 (Pl.12, figs.2a-d), figured Nicholson & Etheridge 1878, pl.8, fig.1, complete dorsal shield; BM In23206 (Pl.12, figs.19a,b), figured Nicholson & Etheridge 1878, pl.8, fig.3, pygidium.

Material, localities and horizons. All the major British palaeontological museums have good collections of this species and no attempt is made to give a comprehensive list. Details of specimens figured herein are as follows. From the type locality: HM A796 (Pl.11, fig.12), GSM 32933 (Pl.12, figs.3a-c), complete specimens; BM In46586 (Pl.12, figs.10a,b), BM In46585 (Pl.12, fig.13), cranidia; BM In23501 (Pl.12, fig.14), free cheek, figured Reed 1906, pl.19, fig.11 as *Cheirurus* (*Youngia*) *trispinosus* Young; GSM 4212 (Pl.12, fig.16) BM In46605 (Pl.12, fig.18), In46602 (Pl.12, fig. 20), pygidia. From Wood Burn Formation, Locality 21: BM In23204 (Pl.12, figs.6a,b) cephalon, thorax and hypostome; BM In23154 (Pl.12, fig.5), YH B101 (Pl.12, fig.11), cranidia; YH B30 (Pl.12, fig.4), YH B61 (Pl.12, fig.7), YH B94 (Pl.12, fig.8), YH B21 (Pl.12, fig.12), free cheeks; YH B58 (Pl.12, fig.9), hypostome; YH B105 (Pl.12, figs.15a,b), YH B20 (Pl.12, fig.17), pygidia. This species can also be collected from Wood Burn Formation, Locality 20 and ?Lauchlan Formation, Locality 23.

Diagnosis. Glabella expanding rapidly anteriorly. Glabellar tubercle formula: II-1^{*}_{*}; iii-0; III-1. Lateral glabellar lobes approximately same size as tubercles on rest of glabella. Anterior border of cranidium with single row of 10 to 14 tubercles. Very short, or absent, genal spine. Field of free cheek with one row of tubercles. Pygidium with 8 pairs of pleural ribs with single adaxial tubercle. 16 to 19 axial rings, effaced medially, with 4 or 5 large median tubercles.

Dimensions of lectotype. Sagittal length, 10.7mm; sagittal length of cranidium, 3.6mm; width across base of glabella, 1.5mm; sagittal length of pygidium, 3.4mm; width across anterior margin of pygidium, 4.6mm.

Description. Cephalon little over twice as wide (tr.) as long (sag.), width taken at posterior border. Glabella twice as long (sag.) as width (tr.) between 2L lobes, expanding anteriorly to over twice width across 2L lobes. Occipital ring 6 times wider than long. Occipital apodeme short and oval in outline. Occipital furrow combined with 1S medially producing broad furrow between occipital ring and 2L. 1L present only laterally as small ridge between occipital apodeme and 1S apodeme. 2L, 3L and 4L inflated, the size of tubercles on rest of glabella, ellipital in outline. 1S apodeme, circular in outline, long and larger than occipital apodeme. 2S apodeme, oval in outline, long; 2S furrow, distinguishable only between 2L and 3L. 3S lacking apodeme; 3S furrow present only between 3L and 4L. Preglabellar furrow very deep and wide, terminating by very wide and deep anterior pit. Tubercle formula: II-1^{*}_{*}; iii-0; III-1; ii-0 rarely present. Anterior border of cranidium with single row of 10 to 14 tubercles with PL as large as 4L. Occipital ring and all furrows lack sculpture. Remainder of glabella with irregularly placed tubercles approximately equal in size to lateral glabellar lobes. Fixed cheek subtriangular in outline. Posterior border short (exsag.) adaxially, lengthening abaxially, and projected into very short genal spine which is probably not present on larger specimens. Posterior border furrow broad and shallow, shallowing abaxially. Lateral border present only close to genal angle, merging with posterior border. Anterior section of facial suture running diagonally forwards from eye crossing axial furrow at anterior pit and defines outline of anterior border of cranidium. Posterior section of facial suture crosses lateral border opposite occipital apodeme. 4 tubercles overhanging axial furrow alternating in position with lateral glabellar lobes. Remainder of convex part of cheek with few large tubercles and small shallow pits crudely radially arranged around base of eye socle. Posterior border external surface with no tubercles, but internally with 1 or 2 faintly raised tubercles. Posterior border furrow free of sculpture. Pedunculate eye 1 1/3 times higher than wide; eye socle cylindrical; visual surface tapering to blunt point dorsally. Free cheek gently convex, twice as long (exsag.) as wide, width taken at position of eye. Lateral border of free cheek wide (tr.), just over ¼ width of free cheek at eye position; expanding rapidly anteriorly and then narrowing to join anterior border of cephalon. Single row of large tubercles on lateral border, gradually decreasing in size anteriorly. Most of anterior border tubercle free. Lateral border furrow broad and shallow but deeper between field of free cheek and precranidial lobe, shallowing and narrowing considerably to anterior border. Field of free cheek sloping gradually away from base of eye socle to lateral border furrow of free cheek. Sculpture as one row of 5 or 6 tubercles radially arranged around base of eye socle but some way from it, with one other tubercle positioned posteriorly and abaxially to above row of tubercles. Field of free cheek also with shallow pits randomly arranged. At base of eye socle pits more elongate in outline and radiating outwards towards row of tubercles. No impression of pits seen on internal surface. Precranidial lobe with 2 vaguely defined rows of large tubercles nearest to anterior furrow, row of smaller tubercles furthest from anterior furrow. All tubercles and lateral and anterior borders very finely granulated.

Rostral plate unknown.

Hypostome approximately as wide across anterior wings as long. Middle body greatly inflated, 1 1/5 times wider (tr.) than long, rhyncos projecting forwards as far as anterior border furrow, narrowing rapidly anteriorly. Shallow furrow at side of steep slope of anterior lobe, running backwards and slightly outwards, dying out opposite anterior wing. Anterior border furrow short (exsag.) and deep medially, lengthening and shallowing laterally. Anterior border narrow and inflated. Lateral border not known; lateral border furrow broad and shallow. Posterior border and furrow unknown. Macula oval in outline. Anterior wing of hypostome with outer tip twisted and deflected outwards and backwards. Surface, except in furrows, very finely granulated.

Thorax of 11 segments. Axis $\frac{1}{4}$ width (tr.) of thorax. Central half of axial ring arched forwards; posterior margin transverse. Inner $\frac{1}{2}$ of pleural field horizontal, outer flexed steeply down and backwards. Posterior pleural band parallel-sided for horizontal region, tapering to backwardly pointing tip laterally. Anterior pleural flange short (exsag.) on inner region, increasing markedly in length (exsag.) laterally. All surfaces with very fine granulation.

Pygidium triangular in outline, usually as wide as long, sometimes a little wider than long. Pygidial axis 5/6 length (sag.) of pygidium, $\frac{1}{4}$ width (tr.) of anterior margin, tapering to $\frac{1}{4}$ anterior width posteriorly, medial $\frac{1}{4}$ of axial width flat or possibly grooved, abaxially sloping steeply to axial furrow. 16 to 19 axial ring furrows deeply incised abaxially but absent for medial $\frac{1}{4}$ of axis, on internal mould anterior 3 or 4 axial rings almost complete. Up to 5 large median tubercles present on axial rings, most commonly on 1st or 2nd, 5th, 9th, 13th or 14th rings. 8 pleural ribs expanding slightly distally; anterior 4 ribs with free lateral margins, distal parts of posterior 4 ribs fused to form posterior border; progessively curving inwards posteriorly with most posterior pair merging behind tip of axis; possible presence of postaxial ridge between posterior pair of ribs. First pleural rib and first axial ring separated by axial furrow. Pleural rib divided by broad furrow, All surfaces very finely granulated, pleural rib with tubercle adjacent to axial furrow, increasing in size on successive posterior pleurae.

Discussion. Nicholson & Etheridge (1878, p.108) in their description of material in the Gray collection assigned all encrinurines from the Girvan area to either Encrinurus punctatus var. arenaceus Salter, 1853 or E. punctatus var. calcareus Salter, 1853; they accepted Salter's distinction that the latter variety was distinguished from the former by the possession of a mucronate pygidium. Only E. punctatus var. arenaceus was figured (pl.8, figs.1-4), and the specimens of figures 1 and 3 were said to be from Penkill (Locality 22) and the specimen of figure 4 from the Craighead Quarry (NS 2347 0136), Caradoc age, Girvan. The specimen of figure 2 was stated to be from Mulloch Hill although no reference was made to Mulloch Hill in their locality list for E. punctatus var. arenaceus (p.110).

Reed (1906, pp.120-22) assigned the encrinurines from the Ordovician and Silurian rocks of Girvan to the same two varieties:

a. E. punctatus var. calcareus. All specimens from Localities 22, 21, 14 and 19 (Penkill, Bargany Pond Burn, Newlands and Camregan Wood respectively) were assigned to this variety. The pygidium of this variety, he considered, possessed medially incomplete axial rings with a sagittal tubercle every 5th or 6th ring and some, a terminal mucro. He noted that the specimens were like the typical Wenlock Limestone examples from Dudley especially in the pygidia. Two of the specimens figured by Nicholson & Etheridge (1878, pl.8, figs.1,3) from Penkill were quoted as examples of this variety.

b. E. punctatus var. arenaceus. Reed assigned all the encrinurines from the

Ordovician rocks and those from Mulloch Hill and Woodland Point (Locality 18) from the Silurian to this variety. They all had, in his opinion, pygidial axial rings continuous across the axis and no median tubercles. Reed quoted Nicholson & Etheridge's figured specimen (pl.8, fig.2) from Mulloch Hill as an example.

In a later paper Reed (1931a, p.19) separated the specimens from Mulloch Hill and Woodland Point from E. punctatus as they had continuous pygidial axial rings and no tubercles, characters not seen in the species of which he had formerly considered the specimens a variety. He proposed the name E. mullochensis for those specimens from Mulloch Hill and Woodland Point. He did not designate a type specimen, or type series.

Whittard (1938, p.122) referred an encrinurine from the Pentamerus Beds (Fronian) and Purple Shales (Telychian) of Shropshire to E. mullochensis Reed. In his description he assumed the figure of Nicholson & Etheridge (1878, pl.8, fig.2) to be the type of the species, and stated: "the type of this species is ill preserved (BM In23175); it has suffered damage since Nicholson & Etheridge described and figured it.....", thereby recognizing that this figure did not agree closely with presumed specimen.

Temple (1970, pp.66-68) referred an encrinurine from Tanhouse, Meifod (upper Rhuddanian) to E. cf mullochensis. In his remarks (p.68) concerning the type specimen of mullochensis he states: "The registration number of Nicholson and Etheridge's specimen is in fact In23172, and Whittard's sentence should be construed as the designation of this specimen, In23172, as lectotype of E. mullochensis."

However, specimen In23210 from Penkill agrees exactly with Nicholson & Etheridge's figure (1878, pl.8, fig.2) and not In23172 or In23175 from Mulloch Hill. The label associated with specimen In23210 and the register gives the locality as Penkill and lithology of the specimen is consistent with other specimens also in Mrs Gray's collection from that locality. Confusion initially arose between these three specimens when Nicholson & Etheridge gave the incorrect locality for their figure ie. Mulloch Hill instead of Penkill.

The specimen represented in Nicholson & Etheridge's figure (1878, pl.8, fig.2) must stand as the lectotype of E. mullochensis so that specimen BM In23210 from Penkill is the lectotype for E. mullochensis. E. mullochensis does not occur at Mulloch Hill (cyphus Zone) nor does the form from Mulloch Hill occur at Penkill (sedgwickii Zone). This creates the situation whereby the species name reflects a locality at which it has not been found.

The specimens from Shropshire referred by Whittard to E. mullochensis (1938, p.122, pl.5, figs.1-5) can be differentiated from E. mullochensis by the presence of well developed genal spines, only a gently expanding glabella, 9 or 10 tubercles on anterior margin of cranidium and tubercles on 1st, 4th, 7th, and 10th axial rings of pygidial axis.

2. Encrinurus squarrosus sp. nov. Pl.13, figs.1-21; Text-fig.24.

Name. Latin 'squarrosus', meaning rough with processes; pertaining to the tubercles on the cephalon.

1882 Encrinurus punctatus; Lapworth, p.627,642 [List].

1899 Encrinurus punctatus (Brün); Peach & Horne, p.529,542 [List].

1899 Encrinurus punctatus var. arenaceus (Salt); Ibid., p.529,530,532, 543 [List].

1899 Encrinurus punctatus var. calcareus (Salt); Ibid., p.543 [List].

1906 Encrinurus punctatus (Brünnich) var. arenaceus; Reed, p.120 (pars)

1931a Encrinurus mullochensis nom prop; Reed, p.19.

Holotype. HM A5368, Pl.13, figs.1a-c, almost complete internal mould of dorsal shield with counterpart; from Newlands Formation, Locality 14 (Newlands Farm).

Material, localities and horizons. Numerous specimens belonging to this species are available in the major British palaeontological collections and no attempt is made to give a comprehensive list. Details of figured material herein are as follows. From the type locality: BM In43121 (Pl. 13, figs.2a,b), HM A1010a (Pl.13, fig.7), HM A10298 (Pl.13, fig.13), cranidia; YH NW74/25 (Pl.13, fig.3), free cheek; HM A799/3 (Pl.13, fig.8), BM It9098 (Pl.13, fig.11), BU 10 (Pl.13, fig.12) , hypostomes; YH NW74/20 (Pl.13, figs.14a,b), BM In43109 (Pl.13, fig.17), HM A5696 (Pl.13, fig.19), YH NW74/23 (Pl.13, fig.20), HM A548 (Pl.13, fig.21), pygidia. From Mulloch Hill Formation, Mulloch Hill (Localities 8 or 9): BM In23175 (Pl.13, figs. 4,5), cranidium; BM In23172 (Pl.13, fig.6), almost complete specimen; BM In47744 (Pl.13, figs.9a,b), free cheek; BM In23220 (Pl.13, fig.15), pygidium. From Woodland Formation, Locality 18: YH WB12 (Pl.13, fig.10) cranidium; YH W8 (Pl.13, fig.16) free cheek; SM A35126 (Pl.13, fig.18), pygidium. This species can also be found at Mulloch Hill Formation, Localities 6, 7 and 10; and Newlands Formation, Locality 11.

Diagnosis. Glabella expanding a little forwards. Lateral glabellar lobes overhanging axial furrows twice size of tubercles on convex surface of glabella. Tubercle formula: I-1; ii-0; II-1; ii-0 not always present. 12 to 14 tubercles on anterior border of cranidium. Genal spine only in small specimens. Field of free cheek with 4 rows of tubercles. Hypostome with long (sag.) and blunt rhyncos, and long (sag.) posterior border. Pygidium non-mucronate with 7 to 11 pleural ribs; 18 to 26 axial rings more or less effaced medially; 5 or 6 small median axial ring tubercles.

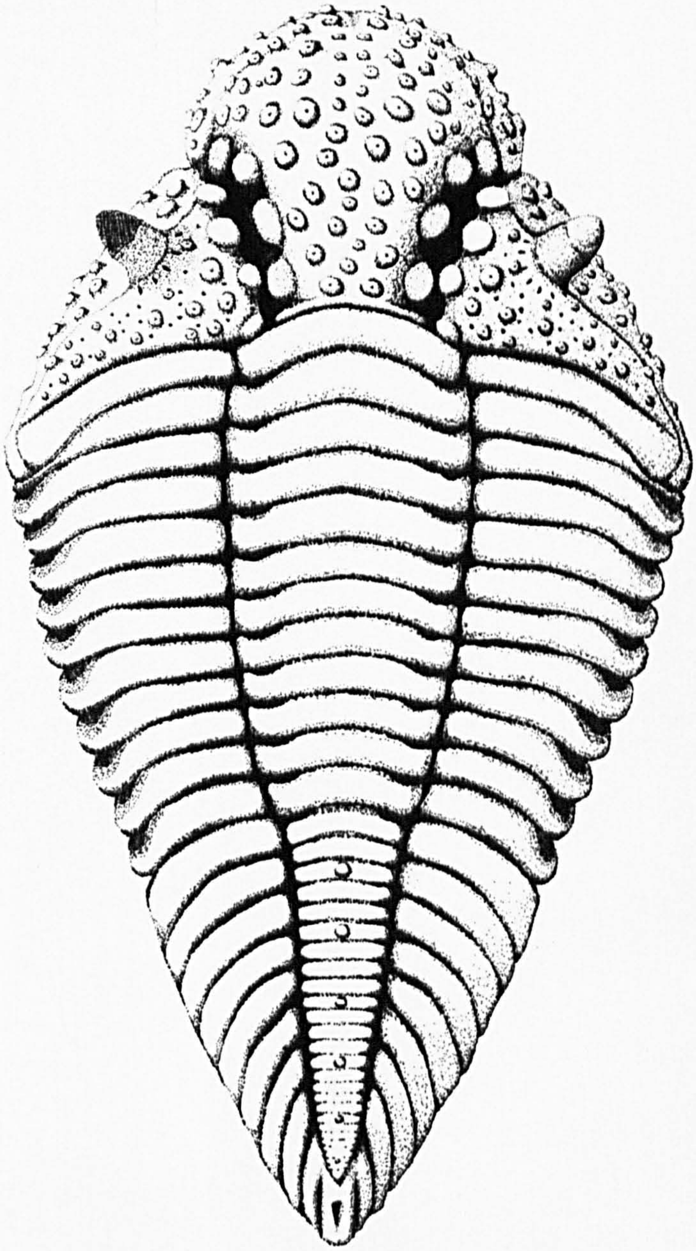
Dimensions of holotype. Almost complete dorsal shield: sagittal length, 34mm; maximum width of cephalon, 20mm; anterior width of pygidium, 20mm.

Description. Glabella expanding gradually forwards to twice width across 2L lobes. Occipital apodeme long, circular in outline. 1L ridged and lying obliquely to sagittal line with posterior limit abaxial, becoming indistinct mesially. 1S apodeme ridge-shaped in outline. 2S apodeme circular in outline; 2S furrow shallow and present laterally only. Glabellar surface coarsely granulated with little organized arrangement except posteriorly. Tubercle formula: I-1; ii-0; II-1 (ii-0 not always present). 2L, 3L and 4L much larger than glabellar tubercles and roughly circular in outline. Anterior border of cranidium with complete row of 12 to 14 tubercles and PL slightly smaller than 4L. Glabellar tubercles significantly smaller in size than glabellar lobes. Some glabellar tubercles with apical pores. All glabellar tubercles finely granulated. Occipital ring, furrows and surfaces between tubercles without sculpture. Short genal spine present in smaller specimens. Most convex part of fixed cheek coarsely granulated, but free of sculpture at base of eye socle. Posterior border tuberculate near genal angle, but with row of tubercles on internal mould. Posterior border furrow without sculpture. Pitting between tubercles denser around base of eye socle and around base of posterior swelling overhanging axial furrow. Pedunculate eye large, oval in outline. Eye socle enlarged at base of visual surface. Field of free cheek coarsely and densely tuberculate, tubercles crudely arranged in 3 or 4 rows concentric to lateral border furrow, shallow pits, more numerous anteriorly, and with elongate depressions radiating outwards from base of eye socle. Lateral border with 2 rows of slightly raised tubercles adaxially. Precranidial lobe with coarse tubercles vaguely arranged in 3 or 4 rows concentric to anterior furrow. Anterior border of cephalon non-tuberculate. Tubercles, lateral border of free cheek and anterior border of cephalon finely granulated; all remaining surfaces without sculpture.

Rostral plate unknown.

Hypostome diamond-shaped, 1 1/3 times longer than wide, rounded anteriorly. Middle body oval, 2/3 length of hypostome, inflated; rhyncos projecting beyond limits of rest of middle body, almost parallel-sided, rounded anteriorly and fading out posteriorly. Macula narrow and inflated. Anterior border short (sag.); anterior border furrow narrow (sag.) lengthening laterally. Anterior wing large, deflected outwards and vertically; wing process circular in outline, laterally situated. Lateral border narrow at midlength of hypostome, subparallel-sided for a distance, narrowing adaxially. Posterior border ¼ length of hypostome tapering to blunt point. Surface of middle body granulate, lateral and posterior border more finely granulate.

Thorax of 11 segments, similar to those of <u>E. mullochensis</u> except



TEXT-FIG.24. *Encrinurus squarrosus* sp. nov., reconstruction of dorsal shield. Typical sagittal length, 34mm.

that posterior band of thoracic segment with row of faint tubercles on internal mould only.

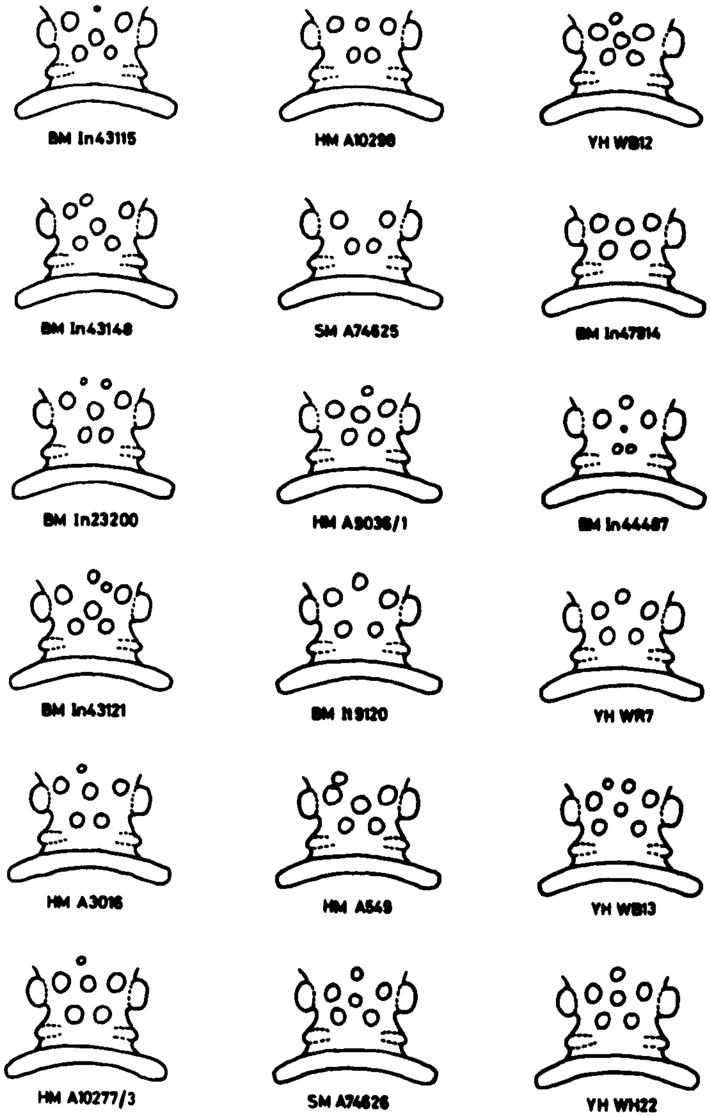
Pygidium, triangular in outline, approximately $1\frac{1}{4}$ times longer than wide. Axis 1/5 width of pygidium at anterior margin, steep-sided, almost flat topped, narrowing gradually backwards to a point, with 18 to 26 axial rings. Anterior 2 ring furrows complete across; behind this progessively indistinct medially. 5 or 6 sagittal tubercles present on axis, usually on

3rd, 6th, 10th, 14th and 19th rings and one close to posterior tip of axis. Pleural regions curve steeply downwards. Pleural ribs, 7 to 11 in number, 10 most common. Anterior ribs expanding slightly laterally and projecting beyond lateral margin of pygidium, posterior ribs merge with lateral margin. Most posterior pair curving inwards distally to merge behind tip of axis. Postaxial ridge present. Rib furrows deep, anterior 5 or 6 reaching lateral margin anteriorly, posterior 4 or 5 dying out before lateral margin posteriorly. All external surfaces very finely granulated. Axial tubercles often more distinct on internal moulds although clearly distinguishable on external casts.

Variation. Glabellar tubercle ii-0 is not always present (Pl.13, fig.4; Text-fig.25) but in the majority of the specimens it is exactly half way between I-1 and II-1; in some specimens it is located at various positions between this and opposite II-1 (see Text-fig.25).

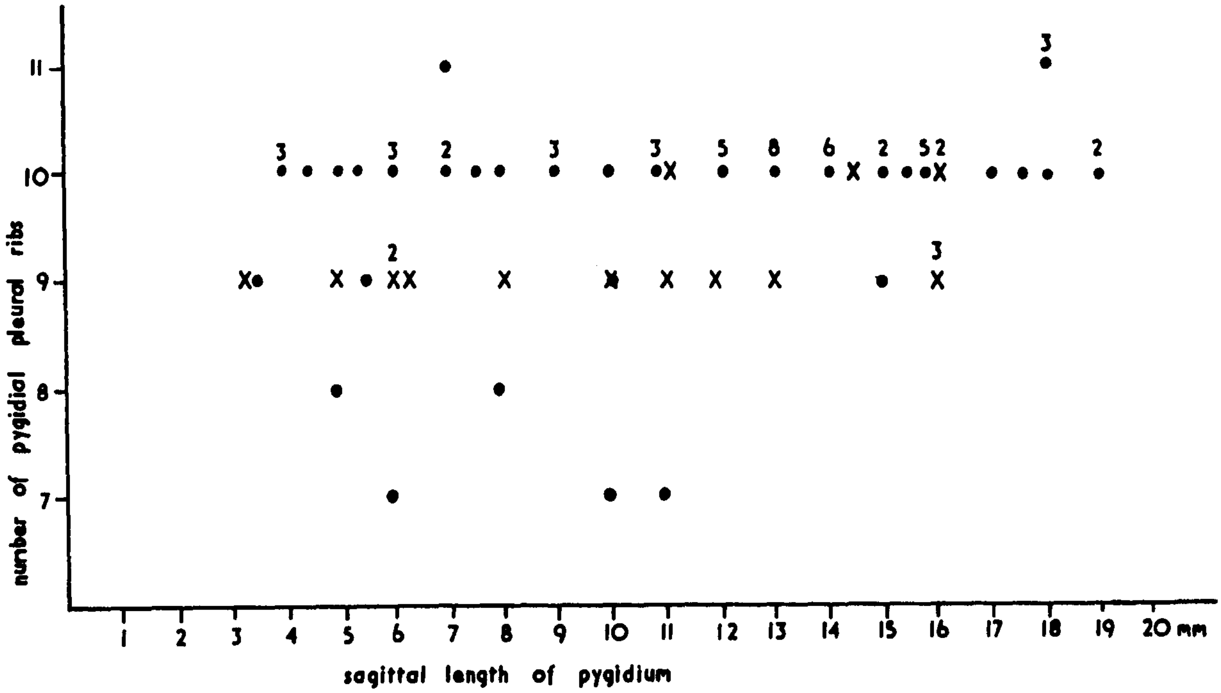
The number of pleural ribs and axial rings present in the pygidium is variable. Of the pygidia 80% have 10 pleural ribs and between 19and 26 axial rings, although it is difficult to count all the rings as they become progressively indistinct posteriorly, There appears to be no relationship between the pleural ribs and axial rings on any one pygidium. The lowest number of ribs recorded in specimens is 7; such specimens have between 15 and 21 axial rings. Four pygidia in the sample have 11 pleural ribs and these have between 22 and 24 axial rings. The size of pygidium apparently has no bearing on the number of pleural ribs that it possesses (see Text-fig. 26). Although the usual number of pygidial pleural ribs is 10, the common number in specimens from Locality 18 (Woodland Point) is 9. This is not considered a specific distinction as the remainder of the dorsal shield does not show any significant differences from other specimens from other localities attributed to the species.

A study after Best (1961) of the frequency with which tubercles are found on each pygidial ring was carried out on the specimens from Locality 14 (Newlands Farm). Encrinurus ornatus Hall & Whitfield, 1875 studied by

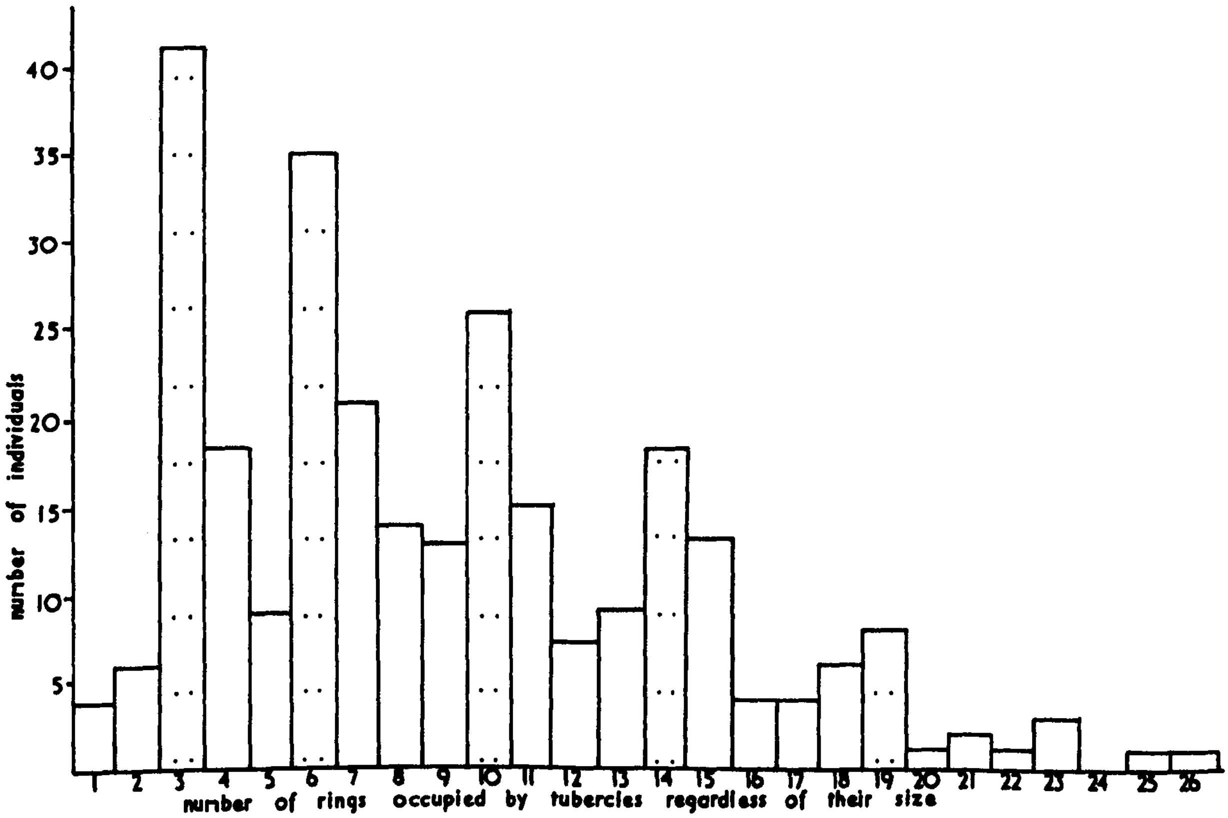


TEXT-FIG.25. Encrinurus squarrosus sp. nov., sketch diagrams to show the variation of tubercle ii-0. Two left-hand columns are specimens from Locality 14; the right-hand column are specimens from Locality 18.

Best (1961, text-fig.1), shows a tendency for the tubercles to occur at regular intervals (on 2nd, 6th, 10th, 14th, 18th, and 22nd axial rings) with inceasing irregularity of the spacing posteriorly. A histogram for the pygidia from Locality 14 shows a similar result of the cyclic nature of the spacing of the tubercles (see Text-fig.27), with a regular arrangement of tubercles (on 3rd, 6th, 10th, 14th, 19th, and 23rd axial rings).

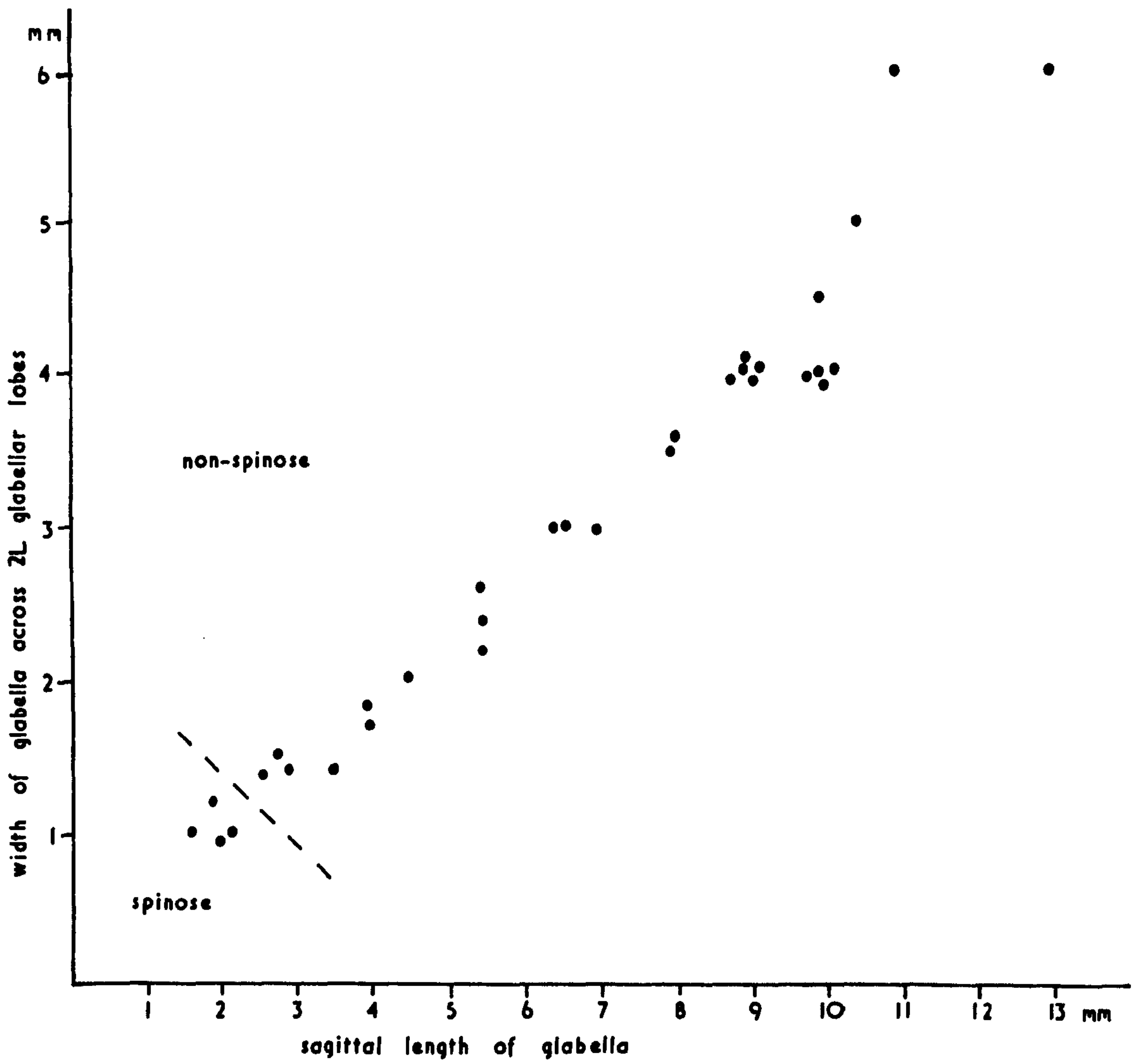


TEXT-FIG.26. Relationship between sagittal length of pygidium and number of pleural ribs of E. squarrosus sp. nov. Circles represent specimens from Locality 14 and crosses represent specimens from Locality 18. Small numbers against crosses or circles indicate where more than one specimen plots at a single point.



TEXT-FIG.27. Histogram to show frequency distribution of tubercles on axial rings of 67 pygidia of E. squarrosus sp. nov. from Locality 14.

Specimens with a sagittal length less than 2.5mm possess genal spines (see Text-fig.28). The gradual loss of genal spines with increase in size is a regular occurrence in encrinurines and other groups of trilobites eg.Phacopidae.



TEXT-FIG.28. Graph showing the size of cranidium at which specimens of Encrinurus squarrosus sp. nov. from Locality 14 lose their genal spines.

A very few pygidia of this species show irregularity of ribbing ie. two ribs coalescing (eg. HM A5696 (Pl.13, fig.19), YH NW74/23 (Pl.13, fig.20)). Hughes (1969, p.77) also noticed ribbing irregularities in Cnemidopyge although a greater proportion of specimens were affected. Because so many were affected he concluded that although some irregularities must be pathological most must represent an inherent factor. The few occurrences in squarrosus may indicate an injury during growth although there is no evidence of repair. However, it is more likely to be a pathological feature.

All the encrinurine hypostomes found at Locality 14 have been assigned to *E. squarrosus* sp. nov., this being the commonest encrinurine present. Small hypostomes (BM In43142, HM A3831, BM In23124 and BU 16) differ a little from larger specimens in that they are shorter and wider, relatively, and the rhyncos is more pointed anteriorly. However, they all possess the elongate posterior border which is characteristic of *squarrosus* and it is considered that these smaller specimens belong to immature individuals.

Discussion. *E. squarrosus* sp. nov. is similar to *E. shelvensis* Whittard, 1938 (p.124, pl.5, figs.6,7) from the Purple Shales (Telychian) of Shropshire, in the gradually expanding glabella. They differ in that *shelvensis* has only 8 tubercles on the anterior border of the cranidium, a tubercle formula of II-0, 1^{*}_{*}, 2; iii-0, III-0*, 1, 2^{*}_{*}, 3; iv-1,2, and a less rapidly tapering pygidium. *E. squarrosus* also differs from *E. mullochensis* Whittard (1938, p.122, pl.5, figs.1-5) from the Pentamerus Beds (Fronian) and Purple Shales (Telychian), Shropshire, in having a more tuberculate cranidium, 1L more strongly developed, the glabellar tubercle ii-0 invariably present, the genal spine absent on mature specimens, more axial rings and pleural ribs in the pygidium and smaller tubercles on the pygidial axis.

Temple (1970, p.66, pl.19, figs.1-10) described an encrinurine from Tanhouse (Lower Llandovery), Meifod which he termed *Encrinurus* cf. *mullochensis* and which he considered similar to the form from Mulloch Hill and Woodland Point. However, the Meifod form differs from *squarrosus* in that 1L is present as a very small tubercle, only one tubercle is present between the palpebral lobe and axial furrow (*squarrosus* has one anteriorly and two posteriorly), the tubercles on the lateral border of the free cheek are better defined, the pygidial axis is relatively wider and there are no tubercles on the pygidial axis

3. Encrinurus stateratus sp. nov.   Pl.14, figs.1-7.

Name. Latin 'statera', meaning steelyard; alluding to the shape of the cranidium.

v.1879 Encrinurus punctatus Brünnich var. calcareus Salter; Nicholson & Ehteridge, p.108,205, pl.10, fig.7.

1906 Encrinurus punctatus (Brünnich) var. calcareus; Reed, p.120, (pars)

Holotype. BM In23209, Pl.14, fig.3, internal mould of cranidium; from Wood Burn Formation, Locality 22 (Penkill).

Paratypes. From type locality: BM In23207 (Pl.14, fig.4), figured Nicholson & Etheridge 1879, pl.10, fig.7, BM In46619 (Pl.14, figs.2a,b), In46620, cranidia; BM In46599 (Pl.14, figs.6a,b), In46600, In46601, HM A50/1 (Pl.14, fig.7), pygidia. From Wood Burn Formation, Locality 21: GSM 32930, YH B125, YH B46, HM A10281 (Pl.14, fig.1), cranidia; GSE M2632[a] (Pl.14, figs. 5a,b), pygidium. From Wood Burn Formation, Locality 20: YH PW4 cephalon; YH PW9,10, pygidia.

Diagnosis. Glabella expanding rapidly anteriorly. Glabellar tubercles approximately same size as lateral glabellar lobes. Lateral part of fixed cheek wide and short and bearing genal spine. Tubercle formula: II-1; III-1; iv-0, IV-1. Pygidium with first axial ring confluent with first pleural rib, and mucronate.

Dimensions of holotype. Cranidial sagittal length, 10mm.

Description. Cranidium (known only as internal mould) almost 3 times wider (tr.) posteriorly than long (sag.). Glabella as long as anterior width narrowing posteriorly to 1/3 anterior width across 2L. Occipital ring as wide as width across 4L lobes, 3½ times wider (tr.) than long (sag.). Occipital apodeme low and circular in outline; occipital furrow completely merged with 1S to produce broad furrow between occipital ring and 2L. 1L seen only laterally as very small swelling between occipital apodeme and 1S apodeme. 2L, 3L and 4L oval, transverse and of equal size. 1S apodeme oval, low. 2S apodeme circular, shallow; 2S furrow visible laterally between 2L and 3L. 3S apodeme circular, smaller than 2S, shallow; 3S furrow visible laterally anterior of 3L. Anterior border with row of approximately 9 to 11 tubercles and with PL slightly smaller than 4L. Preglabellar furrow visible laterally as broad depression anterior of 4L. Axial furrow deep and flat bottomed, terminating anteriorly at wide and shallow anterior pit. Glabellar surface coarsely tuberculate; II-1; III-1, iv-0; IV-1; always present. Lateral glabellar lobes a little larger than glabellar surface tubercles. Fixed cheek 1 1/3 times wider (tr.) than long (exsag.) adaxially, and produced into short, backward pointing genal spine. Adaxial ½ of fixed cheek inflated, abaxial ½ flattened. Posterior border lengthening (exsag.) laterally to 1/3 length of flattened part of cheek. Posterior border furrow shallow, lengthening (exsag.) abaxially but dying out before genal spine. Anterior section of facial suture runs diagonally forwards from eye, crossing axial furrow just anterior of anterior pit and defines outline of anterior border. Posterior section of facial suture straight and transverse from position of eye, abaxial limit unknown. Four tubercles overhanging axial furrow; raised part of fixed cheek with scattered tubercles irregularly arranged around base of eye socle. Rest of free cheek unsculptured.

Free cheek, visual surface, rostral plate, hypostome and thorax unknown.

Pygidium triangular in outline, 1 1/3 times wider (tr.) than long (sag.) to base of mucro. Axis weakly convex, 1/5 anterior pygidial width, tapering posteriorly and merging into mucro. First axial ring confluent with first pleural rib. At least 19 axial rings; first 3 ring furrows complete, posteriorly indistinct medially. 8 pleural ribs, laterally bending steeply downwards, posterior most ribs almost vertical. Anterior 4 ribs free ended, posterior ribs merge with lateral margin, eighth pair merges posteriorly with mucro. Complete mucro not preserved but base flexed upwards. Pygidial axis with 4 or more small median tubercles. Sculpture of remaining surfaces not known because of poor preservation.

Discussion. This species probably falls within the E. punctatus (Wahlenberg, 1821) species group as defined by Tripp (1962a, p.460) in that the glabella widens markedly anteriorly, 1L is almost obsolete, the anterior border of cranidium has a single row of tubercles, the genal spine is well developed, the pygidial axis has a row of median tubercles, and the pygidium has 8 pairs of pleural ribs. E. stateratus however can be distinguished from other members of the species-group by the lack of glabellar tubercles behind II-1, the almost obsolete 1L, the very wide (tr.) and short (sag.) field of free cheek, and the upturned pygidial mucro.

4. Encrinurus confusevarus sp. nov. Pl.14, figs.8-15.

Name. Latin 'confuse', meaning in a disorderly manner, and 'varus' meaning pimple; pertaining to the random arrangement of the tubercles on the posterior of the glabella.

1882 Encrinurus punctatus; Lapworth, p.647 [List].

?1899 Encrinurus punctatus (Brün); Peach & Horne, p.540 [List].

Holotype. BM In23189, Pl.14, fig.8, internal mould of cranidium; from Lower Camregan Grits, Locality 19 (Camregan Wood).

Paratypes. From type locality: SM A35152, RSM 1958.1.2577, GSE JS17937, YH C71 (Pl.14, fig.12), cranidia; BM In23190 (Pl.14, fig.13), In23188 (Pl.14, fig.10), SM A35153, GSM d927, GSE JS17947, YH C90 (Pl.14, fig.15), GSE JS17948, GSE M3131[b], pygidia; YH C102 (Pl.14, fig.9), free cheek. From Lower Camregan Grits, Locality 16: HM A9115/1 & 4, HM A9115/2 & 3, cranidia; HM A9118 (Pl.14, fig.11), free cheek; HM A9116 (Pl.14, fig.14) hypostome; HM A9079, A9113/1 & 2, LRMC 1, pygidia.

Diagnosis. Glabella expanding greatly anteriorly. Glabellar tubercles without regular patterning. Anterior margin of cranidium with row of 10 tubercles. Well defined longitudinal median furrow on anterior part of cranidium. Long genal spine. Pygidium with 8? pleural ribs and 20 or more axial rings.

Dimensions of holotype. Sagittal length of cranidium, 8.0mm; width across posterior border, 20.0mm.

Description. Cranidium 2 2/5 wider posteriorly than long. Glabella expanding anteriorly to twice width across 2L, slightly wider than long.

2L, 3L and 4L decreasing in size slightly anteriorly. 1S apodeme, low, oval and oblique with anterior directed abaxially. 2S apodeme longer but smaller than and parallel to 1S. 3S apodeme very low, small and circular. Longitudinal median glabellar furrow well defined, 1/5 length of glabella, cutting through preglabellar furrow. Glabellar tubercles almost as large as lateral glabellar lobes. Anterior border of cranidium with single row of 10 tubercles, with PL as large as 4L; holotype with one extra tubercle in longitudinal median glabellar furrow. External surface too poorly preserved to determine sculpture. Fixed cheek triangular in outline, with slender genal spine approximately equal in length to glabella. Posterior border furrow straight, long (exsag.) adaxially, shallowing abaxially, curving anteriorly adjacent to genal spine. Most convex part of fixed cheek with tubercles crudely arranged into 3 rows; no sculpture immediately around base of eye socle. One large tubercle with few smaller tubercles at base of genal spine. Posterior border and border furrow, and genal spine without sculpture.

Pedunculate eye situated opposite 4L; eye socle narrower at its base with row of tubercles just below lens surface. Field of free cheek and precranidial lobe very narrow. Lateral border and lateral border furrow wide. Anterior and posterior sections of facial suture almost straight. Field of free cheek with one row of tubercles; lateral border with one row of tubercles; precranidial lobe with possibly 2 rows of tubercles.

Hypostome similar to that of _E. mullochensis_; rhyncos might be relatively longer.

Rostral plate and thorax unknown.

Pygidium elongate, but in available specimens the posterior part is poorly preserved. At least 8 pleural ribs, with 20 axial rings present. At least 4 small sagittal median tubercles.

Discussion. The irregularity of tubercles on the glabella, the presence of a longitudinal median glabellar furrow, the narrow free cheek, and the genal spine are sufficient characters to distinguish a new species.

E. confusevarus sp. nov. is very similar to an undescribed encrinurine from the Purple Shales (Telychian) of Shropshire, especially in the form of the genal spine, with a basal tubercle. However, the Girvan form can be distinguished by its lack of regular arrangement of glabellar tubercles at the base of the glabella and by the glabella being narrower and more depressed opposite 1L lobes.

5. Encrinurus cf. E. squarrosus sp. nov. Pl.14, figs.16-19.

Material, locality and horizon. From Wood Burn Formation, Locality 21: YH B68 (Pl.14, fig.17) free cheek; YH B27 (Pl.14, fig.18), BM In23153 (Pl.14, fig.19), GSE 10778, GSE 718, pygidia. BM I5336 (Pl.14, fig.16) is registered as being the specimen represented by Salter (1851, pl.9, fig.4). However, close examination of the figure and the specimen show that this is not so. The figure is of a more complete, unknown, specimen. The lithology of BM I5336 is consistent with those specimens from the base of the Wood Burn Formation in Penwhapple Glen.

Discussion. The free cheek of this form is very close to that of E. squarrosus sp. nov. from the Rhuddanian and Idwian of Girvan in that it has many rows of tubercles on the precranidial lobe, and many pits and tubercles on the field of the free cheek. The pygidium, although superficially similar to squarrosus in the large number of axial rings and small median tubercles, differs in the size of the pleural ribs. In E. cf. E. squarrosus the pleural ribs are much narrower and possess a well defined anterior band (YH B27a, Pl.14, fig.18; BM In23153, Pl.14, fig.19). Of the five pygidia known of this form the commonest number of pleural ribs is 8 which is less than the usual 10 of E. squarrosus.

6. Encrinurus sp. A. Pl.14, figs.20-26.

1899 Encrinurus punctatus (Brün); Peach & Horne, p.550 [List].

1899 Encrinurus punctatus var. arenaceus (Salt); Ibid., p.550 [List].

1906 Encrinurus punctatus (Brünn) var. calcareus; Reed, p.122.

1965 Encrinurus knockgardnerensis Lamont; Lamont, p.37 [nom. dub.].

Material, locality and horizon. From Knockgardner Formation, Locality 24; GSE M2505[a] (2 specimens on one slab), GSE M2502[a], M2693[b], YH 1K3 (Pl.14, fig.20), cranidia; GSE M1020[e], (Pl.14, fig.24), M1016[e] (2 specimens), free cheeks; YH 3K4 (Pl.14, figs.22a,b), hypostome; HM IP30, HM IP22, YH 3K27 (Pl.14, fig.21), YH 3K22 (Pl.14, fig.25), YH 3K28 (Pl.14, fig.26), pygidia. Also from writer's own collection from Locality 24; 9 cranidia, 11 free cheeks, 9 pygidia.

Description. Complete cranidial limits unknown. Glabella approximately twice as long as wide across 2L, expanding gradually anteriorly. Occipital ring $3\frac{1}{2}$ times wider than long. Occipital furrow distinct, narrow. 1L present only laterally as small ridge. 2L, 3L and 4L oval in outline and equal in size. 1S and 2S apodemes circular in outline, small and low. 2S furrow distinguishable only between 2L and 3L. 3S apodeme very narrow and ridge like; 3S furrow present only between 3L and 4L. Anterior border of cranidium delimited by very shallow preglabellar furrow, slightly pointed sagittally. Glabellar tubercle formula: I-1; ii-0,2; II-1. Anterior border of cranidium with single row of 10 (?11) tubercles and PL as large as 4L. Occipital ring and furrows unsculptured. Glabella anterior to 2L with scattered tubercles of irregular size but all smaller than lateral glabellar lobes. Fixed cheek not well known, subtriangular in outline. Posterior border shorter (exsag.) than occipital ring, and border furrow proximally narrow. Anterior section of facial suture running diagonally forward adaxially from eye, crossing axial furrow and defining outline of anterior border of cranidium. Posterior section of facial suture not preserved. 4 large tubercles on fixed cheek overhanging axial furrow alternating in position with lateral glabellar lobes. Proximal raised part of fixed cheek tuberculated.

Eye socle constricted at base, positioned relatively anteriorly opposite 3S furrow of glabella. Free cheek approximately twice as long as wide. Lateral border of free cheek, widest posteriorly, narrowing initially a little and then rapidly where it joins anterior border of cephalon, raised above level of field of free cheek; row of tubercles on adaxial edge of border decreasing in size posteriorly, with incomplete second row abaxially. Anterior border free of tubercles. Lateral border furrow narrow deepening alittle anteriorly. Anterior border furrow very shallow. Field of free cheek depressed and flat, with 2 concentric rows of tubercles decreasing in size posteriorly, and with pits posteriorly. Precranidial lobe on same level as anterior border with 2 rows of tubercles.

Rostral plate unknown.

Hypostome incompletely known. Middle body diamond-shaped in outline, 1 1/3 longer than wide, rhyncos tapering alittle anteriorly. Macula not seen. Anterior border short (sag.), border furrow long (exsag.) but narrow medially. Anterior wing large but not well preserved. Lateral and posterior borders unknown.

Pygidium triangular in outline, approximately as wide anteriorly as long. Pygidial axis 1/3 width anteriorly, narrowing gradually backwards to a point, with approximately 13 axial rings; ring furrows deep laterally shallow for medial third of axis. 4 or 5 median tubercles present sagittally. Pleural regions curve steeply downwards, with 8 or 9 pleural ribs. Posterior pair curve inward distally and merge behind tip of axis, postaxial ridge present between these. Rib furrows deep. Surface sculpture not seen.

Discussion. *Encrinurus* sp. A differs from *E. hagshawensis* Lamont 1965 (p.36, pl.5, fig.4) from the Ree Burn Formation (*crenulata* Zone) Hagshaw Hills, by the latter possessing a more tuberculate glabellar lobe with differing glabellar tubercle pattern, tubercles on lateral glabellar lobes, and more tubercles on the anterior border. The Girvan free cheek differs from *Encrinurus* cf *hagshawensis* (a) Lamont (1965, p.37) also from the Ree Burn Formation in that the latter has a deeper anterior border furrow, a wider field of free cheek with the eye socle more centrally placed, and larger tubercles on lateral border.

Lamont (1965, p.37,38) refers a small *Encrinurus* cranidium to *E.* cf *knockgardnerensis* Lamont sp. nov. (a), and a free cheek and two pygidia to E. cf knockgardnerensis Lamont sp. nov. (b). Lamont gives the impression in his paper that E. knockgardnerensis may have already been described since no description, type specimen or type locality for this species is given. No prior reference to E. knockgardnerensis has been traced in the literature. Consequently E. knockgardnerensis is declared a nomen nudum.

7. Encrinurus? muldooni sp. nov. Pl.15, figs.1-7,9.

Name. From 'Spotty Muldoon' an imaginary character invented by Peter Cook and Dudley Moore, who was incredibly spotty; pertaining to the very tuberculated dorsal shield.

Holotype. RSM 1889.91.17, Pl.15, figs.1a,b, internal mould of incomplete cranidium; from Newlands Formation, Locality 14 (Newlands Farm).

Paratypes. From type locality: YH NW120 (Pl.15, figs.2a-c), YH NW171 (Pl.15, figs.3a-c), YH NW161, NW11, HM A10277/2, Imp. Coll. 1, BM In 43113, In43114 (Pl.15, fig.5), In43146, GSE 5359, HM A1490/2, HM A3069, cranidia; YH NW123, HM A794, HM A7395 (Pl.15, figs.4a,b), BM In43122 (Pl.15, fig.9), free cheeks; HM A1006, BM In43123, HM A3699, YH NW4, Imp. Coll. 2, SM A7463, GSE 5363, GSE 725, SM A35141 (Pl.15, fig.7), BM In43143 (Pl.15, figs.6a,b), ?BM In43161, ?HM A1490/1, pygidia.

Diagnosis. 1L as transverse ridge. Two rows of tubercles on anterior border of cranidium. Tuberculate glabellar lobes overhanging axial furrows. Genal spine long, stout and tuberculate. Tuberculate free cheek with large number of pits. Pygidium with 8 to 10 pleural ribs which bear tubercles on internal mould.

Dimensions of holotype. Cranidial sagittal length, 6.5mm; maximum transverse width known, 14.5mm; width across 2L lobes, 4mm.

Description. Cranidium approximately twice as wide posteriorly as long. Glabella twice as long as wide across 2L, expanding forwards. Occipital ring 6 times wider than long. Occipital apodeme circular in outline; occipital furrow confluent with 1S furrow. 1L as small ridge between occipital and 1S apodemes. 2L, 3L and 4L cylindrical protruberances overhanging axial furrow, equal in size. 1S apodeme oval in outline, transverse. 2S apodeme circular in outline; 2S furrow broad and deep dying out medially. 3S, no apodeme; 3S furrow as 2S but progessing further adaxially across glabellar lobe. Anterior border of cranidium expanding slightly laterally. PL not developed. Preglabellar furrow deep, widening laterally. Longitudinal median glabellar furrow deep behind preglabellar furrow. Axial furrow deep and wide, terminated anteriorly by deep, circular anterior pit. Posterior glabellar tubercle formula: I-1; ii-0,2; II-1; iii-2. Anterior border of cranidium with 2 rows of many tubercles. Surface of glabella, lateral glabellar lobes and internal mould of occipital ring greatly tuberculate; furrows without sculpture. Fixed cheek triangular in outline with genal spine equal in length to width across 3L glabellar lobes. Posterior border same length (exsag.) as occipital ring adaxially, expanding slightly laterally. Posterior border furrow shallowing and curving anteriorly laterally, Anterior section of facial suture running diagonally forwards, at acute angle, crossing axial furrow at anterior pit. Posterior section of facial suture running diagonally backwards crossing lateral border opposite occipital apodeme. No large tubercles overhanging axial furrow. Field of fixed cheek with many tubercles. Posterior border with one row of tubercles on internal mould, but without sculpture on external surface. Pedunculate eye positioned opposite 3L. Eye socle cylindrical with tubercles below visual surface. Complete lens surface not preserved. Free cheek 2 2/3 times wider than long (exsag.), width taken at level of eye. Lateral border of free cheek wide opposite eye dying out at midlength of precranidial lobe; greatly tuberculate, smallest tubercles positioned laterally. Lateral border furrow shallow. Field of free cheek flat with many tubercles and pits randomly arranged, only very slight impression of pits internally. Precranidial lobe also with randomly arranged tubercles.

Rostral plate, hypostome and thoracic segments not known.

Pygidium subtriangular in outline, 1¼ times wider anteriorly than long. Axis ¼ width of anterior margin tapering to a point posteriorly, with sloping sides, medially almost flat. 17 to 23 axial rings, effaced medially posteriorly, small tubercles present on all rings. 4 to 5 larger sagittal tubercles on some rings. 8 to 10 pleural ribs present which bear small tubercles on internal moulds.

Discussion. This species has been placed with reservation in *Encrinurus* since it has some features which could be considered characteristic of *Encrinuroides* Reed, 1931a. Evitt & Tripp (1977, p.122) proposed a diagnosis for *Encrinuroides* based on Whittington's (1950a) redescription of *Encrinuroides sexcostatus* (Salter, 1848) the type species. *Encrinurus? muldooni* agrees with the diagnosis in that it possesses a longitudinal median glabellar furrow, a distinct preglabellar furrow and has a number of pygidial axial rings and pleurae, within the stated range. However, it differs in that although 1L can said to be the shortest lobe it is almost obsolete compared with other members of *Encrinuroides*, and that the anterior border of the cranidium expands laterally.

Encrinurus? muldooni is similar to *Encrinurus tuberculifrons* Weller 1907 (p.259, pl.24, figs.12,13) from the Wenlock Series, Kankakee County, Illinois, which has however, a better defined 1L ridge with small tubercle laterally, a shorter anterior border of cranidium with only one row of tubercles, possibly no genal spine and only 7 pairs of pygidial pleural ribs.

The Girvan species bears some similarity to *Encrinurus princeps* Poulsen 1934 (p.33, pl.3, figs.23-27) from Cape Hamilton and Cape Schuchert, Cape Schuchert Formation (Llandovery), North Greenland. However, the Greenland species differs from *E. muldooni* in having well developed 1L lobes, one row of tubercles on the anterior border of the cranidium, long field of fixed cheek posterior to the eye, and a pygidium much wider than long.

Family CALYMENIDAE Burmeister, 1843

Subfamily CALYMENINAE Milne-Edwards, 1840

Genus Calymene Brongniart, 1822

Type species. Original designation; Calymene Blumenbachii Brongniart, 1822, p.11, pl.1, figs.1A-D; from the Wenlock Limestone of Dudley, England.

Diagnosis and Discussion. See Siveter (1973, p.180).

1. Calymene subdiademata subdiademata McCoy, 1851. Pl.15, figs.8,10-18, 20.

v.1973 Calymene subdiademata subdiademata McCoy, 1851; Siveter, p.182, pl.1, figs.1-14, pl.2, figs.7,9 [with full synonomy].

v.1975 Calymene sp.; Temple, p.140, pl.26, figs.2-4,7,8.

v.1975 Calymene sp. A.; Ibid., p.152, (pars), pl.26, figs.5,6,9,10, non pl.25, figs.9-13,15,16.

Lectotype. Selected Siveter 1973, p.183; SM A34872, Pl.15, fig.20, internal mould of incomplete cranidium; described McCoy 1851, p.166 (pars); figured Siveter 1973, pl.1, fig.9.

Type locality. The locality given in the register for the lectotype is "Mulloch, Dalquharran". The lithology at Mulloch Hill consistent with that of the specimen is that of the Mulloch Hill Formation at localites 3 or 6. Siveter (1973, p.183) mistakenly believed that the lithology of the specimen was like that from the Newlands Formation, Locality 14, (Newlands Farm), because of the strong ochreous weathering of the rock which all three localities possess.

Material, localites and horizons. All the major British palaeontological museums have good collections of this species, and no attempt is made to give a comprehensive list. Details of specimens figured herein are given as follows. From Newlands Formation, Locality 14: BM In23337 (Pl.15, fig.8), YH N618 (Pl.15, fig.9), BM In43673 (Pl.15, fig.12), YH NW57 (Pl.15, fig.13), cranidia; YH NW444 (Pl.15, fig.11), free cheek. From Mulloch Hill Formation, Mulloch Hill (Localities 8 or 9): BM In23331 (Pl.15, figs.14a,b), figured Reed 1906, pl.17, fig.12, YH R80 (Pl.15, fig.15), SM A34873 (Pl.15, fig.18), cranidia; BM In23330 (Pl.15, fig.17), figured Nicholson & Etheridge 1879, pl.10, fig.6, dorsal shield. From Woodland Formation, Locality 18: YH WR166 (Pl.15, fig.16), cranidium. This species is also found at Newlands Formation, Locality 11; and Mulloch Hill Formation, Localities 7 and 10

<u>Diagnosis</u>. See Siveter (1973, p.183).

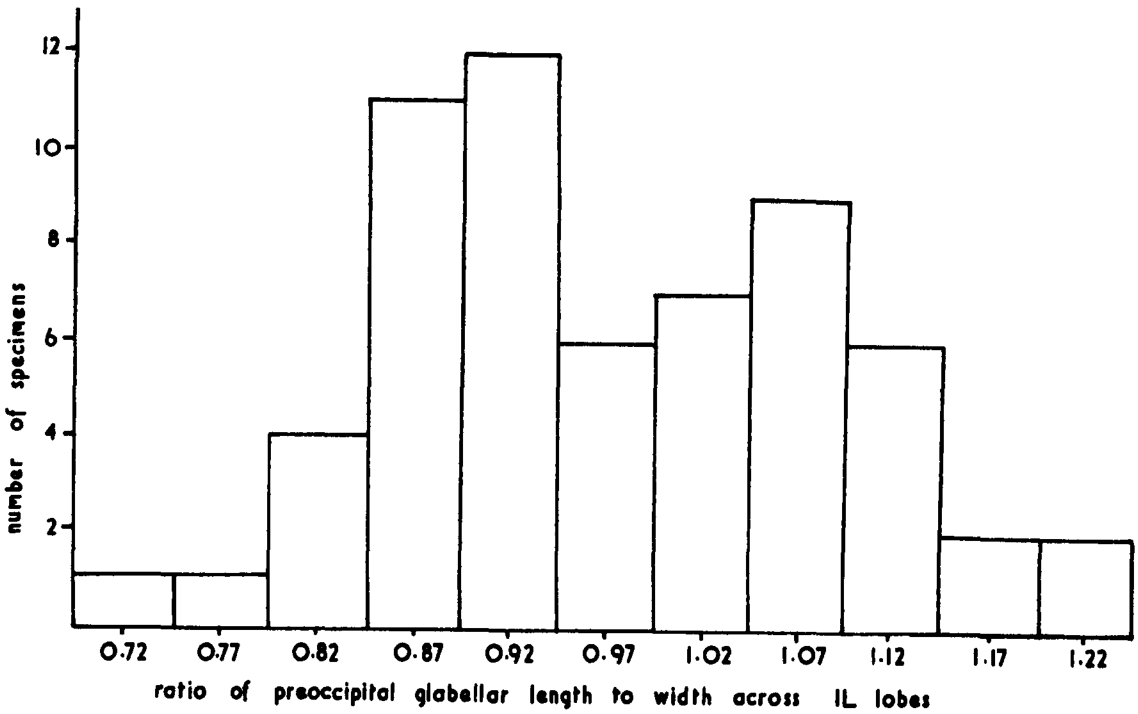
<u>Description</u>. As Siveter (1973, p.183) but with the following additions. Latex rubber casts of external moulds of cranidia (eg. YH R80, Pl.15, fig.15, YH R148 and YH NW77) reveal a slight swelling at the base of the glabella opposite the base of 1L, and the size of the granules on the cranidium decreases with increasing size of the cranidium. Cranidia from Woodland Point (Locality 18) show a coarser granulation to those from Mulloch Hill and Newlands (eg. YH WR16, Pl.15, fig.16).

<u>Discussion</u>. The history of the species and the morphology and relationships of <u>Calymene subdiademata subdiademata</u> are discussed in detail by Siveter (<u>Ibid</u>., p.185).

Temple (1975, pp.137-160) included calymenid material from Locality 14 (Newlands Farm) and from Localities 1 to 9 (Mulloch Hill) in his analysis and description of British Llandovery calymenids. Temple used multivariate components analysis to show that the profile of the preglabellar field differed in specimens from each locality studied and that at each locality there was a dimorphic variation of relative glabella widths. This dimorphism Temple considered to be probably sexual.

a) Preglabellar field. From eigenvector analysis Temple (<u>Ibid</u>., p.141) claimed that from Locality 7132 (along lane leading to Gasworks, Haverfordwest, Dyfed) through Newlands to Mulloch Hill the degree of overhang of the preglabellar area progressively increases. Also he stated (p.143) that cranidia from Wales "have both longer and higher preglabellar areas than Scottish specimens, while among the latter Newlands specimens have longer preglabellar areas than do specimens from Mulloch Hill". Temple considered that the calymenid from Locality 14 (Newlands Farm) was distinct from that of Localities 1 to 9 (Mulloch Hill) in possesseing a more overhanging preglabellar field and smaller preglabellar area. The Newlands form was arbitrarily referred to Calymene sp. A (Temple, p.152, pl.25, figs.9-13,15,16; pl.26, figs.5,6, 9,10) which is based on material from the Gasworks Mudstone, Haverfordwest. Temple considered the Newlands form and Calymene sp. A to be conspecific because of the Newlands sample's overlap with the Welsh sample on the principal components plot. Siveter (1973) believed the Haverfordwest and Girvan material to represent separate forms and he referred them to different genera. The Haverfordwest form differs from that of Newlands in that the anterior border of the cranidium is longer (sag.), the anterior corner to the fixed cheeks projects forwards and inwards, and the glabellar tubercles are more distinguishable. The parameters used by Temple for the differentiation of species are based on measurements of the cranidium (Temple, p.140, text-fig.1a,b) which are often so small as to be particularly subject to error. Temple's cranidium variate x_2 is never more than 3.0mm in length, variate x_3 is never more than 1.5mm and variate x_4 is never more than 0.8mm. These variates present practical difficulties when measuring the specimens because of the small units involved. Also the variates will be readily affected by any slight distortion or flattening of the specimen caused by post-depositional changes.

b) Dimorphism. Temple (Ibid., p.144) considered that for the combined "undistorted" (presumably by this he is referring to those specimens which show no obvious angular distortion) Llandovery specimens (61 specimens) which he measured, the distribution of the ratio of the preoccipital glabellar length to the width across 1L lobes is bimodal about unity. His ratios of the specimens when grouped at intervals of 0.05 between 0.7 and 1.2 (Temple, p.144) plot as given below (Text-fig.29). Temple then subjected this ratio data to further principal components analysis the results of which, according to Temple (Ibid., p.145), showed more convincing clustering into "wide" and "narrow" forms. Temple (Ibid., p.146) also considered that he could detect dimorphism in calymenid pygidia. The ratio of the pygidial characters of a sample of Newlands specimens,

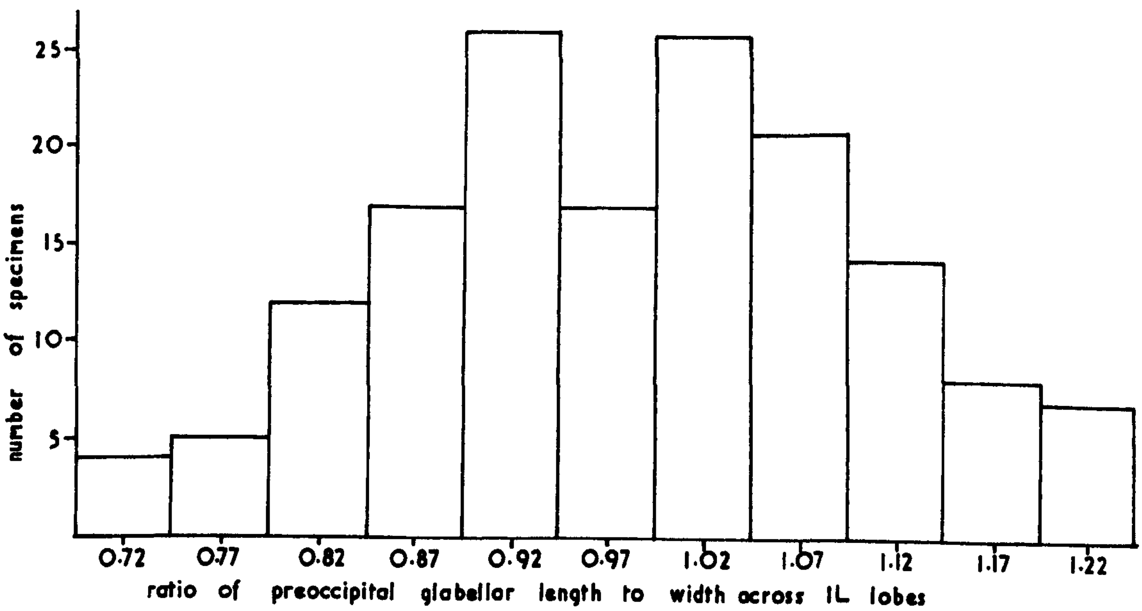


TEXT-FIG.29. Histogram to show the frequency distribution of the ratio of preoccipital glabellar length to the width across 1L lobes in 61 specimens of Llandovery calymenids from Temple's (1975, p.144) results.

$$\frac{\text{transverse separation of bases of rachial furrows at abaxial ends of articulating furrows}}{\text{sagittal length (measured from deepest points of articulating furrow infront) normal projection}}$$

produced a positive skew distribution which he regarded as being indicative of dimorphism. Temple (1975, p.144) considered that the calymenid cranidia from Newlands would provide a sample to test the bimodality of the glabellar width/length ratio since complications due to tectonic or compation distortion are slight at that locality. Nevertheless, in obtaining his data only 36 cranidia out of 81 from the Newlands locality in the collections of BM (NH) were measured, the others presumably having been eliminated as being distorted (Ibid., p.144). What constituted a distorted specimen is not stated but it seems likely that specimens showing angular distortion were discarded. The present author considers that all specimens from Newlands are more or less distorted. Specimens from this locality occur randomly orientated throughout the matrix so that tectonic or compaction distortion have different effects on different specimens. Some specimens will occur sagittally or transversely parallel to the plane of distortion and so if the effect of distortion is slight they will appear undistorted as no angular displacement will be seen. Of Temple's sample of 36 cranidia only 12 were referred to a narrow form and 4 to a wide form (Ibid., p.145).

The frequency of the preoccipital glabellar length/width ratio for 159 calymenid cranidia from Newlands and Mulloch Hill taken from specimens housed in all the major museums and in the writer's own collection, is shown in Text-fig.30. This graph also shows a crude bimodality (cf. Text-fig.29) but is considered to show two peaks of slightly distorted specimens eitherside of relatively undistorted specimens.



TEXT-FIG.30. Frequency of glabella length/width ratio of 159 calymenid cranidia from Locality 14 (Newlands) and Localities 1 to 9 (Mulloch Hill)

If two statistical populations are assumed with Temple's 61 combined Llandovery cranidia (population A and population B eitherside of 0.99) then a Student's t-test on the two populations in comparison with the total population of 159 cranidia can be employed as follows.

Temple 1975:	Population A.	31 specimens. Average ratio, 0.892. Standard deviation, 0.0591.
	Population B.	30 specimens. Average ratio, 1.097. Standard deviation, 0.0612.
Total Girvan population:		159 specimens. Average ratio, 0.98. Standard deviation, 0.1198.

Student's t-test:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)\sqrt{\dfrac{N_1 N_2}{n_1 + n_2}}}{\sqrt{\dfrac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}}}$$

$N_1 + N_2 - 2$ = Number of degrees of freedom = ν

$\bar{x}$ = mean; s = standard deviation; N = number of specimens.

Temple's population A with total population.

$\nu = 188$ $t = 0.088$ For 0.05 probability (95% confidence) $t = 1.9727$

Temple's population B with total population.

$\nu = 187$ $t = 0.1176$ For 0.05 probability (95% confidence) $t = 1.9728$

These results show that the difference of the means of the two populations of Temple to the mean of the total population of 159 cranidia are not significant. Hence Temple's two populations (ie. wide and narrow forms) are extreme end members of the total population which have become increased because of the distortion of the specimens.

The concept of "dimorphism" in Llandovery calymenids as indicated by Temple is regarded here as a function of tectonism and compaction. The two cranidia figured by Temple (Ibid., pl.26, fig.5, pl.26, fig.9) represent "narrow" and "wide" cranidia respectively. It is considered here that these two cranidia show the result of compaction of the cranidia at right angles to the sagittal line ("narrow" form, fig.5), and parallel to the sagittal line ("wide" form, fig.9). Specimen BM In43631 (pl.26, fig.5) shows the posterior part of the fixed cheek of the cranidium to be convex and curving posteriorly, an attitude consistent with lateral compaction; specimen BM In43662 (pl.26, fig.9) shows the posterior part of the fixed cheek to be flattened and transverse, consistent with distortion at right angles with the sagittal line. This compaction in relation to the sagittal line is exemplified by specimen BM In43673 from Locality 14 (Pl.15, fig.12). This specimen shows two incomplete cranidia lying at right angles where the compaction has occurred at right angles to the cranidia. The cranidium on the left has "narrow" characteristics, the cranidium on the right has "wide" characteristics.

Sadler (1974, p.77) in a statistical analysis claimed that there are two variants in Neseuretus (Neseuretus) tristani (Brongniart, 1822) which can clearly be differentiated by their ratio of cephalic axis width and length. The difference between the "W" and "L" forms of Sadler is clearer than the difference between Temple's "wide" and "narrow" forms (cf. Sadler, 1974, p.80, text-fig.5A, and Temple 1975, p.144, text-fig.3). The rocks in which these fossils are found are cleaved and hence could produce two statistical populations eitherside of the undistorted normal for that species.

The present writer is in agreement with Siveter 1973 that all calymenids from the Rhuddanian and Idwian localities at Girvan belong to the same species and that variations are the result of distortion and compaction.

2. Calymene hadyardensis Lamont, 1949 Not illustrated.

v.1949 Calymene hadyardensis Lamont, p.316, pl.18, figs.9-12, ?8.

1970 Calymene hadyardensis Lamont, 1949; Schrank, p.116,131.

v.1973 Calymene hadyardensis Lamont, 1949; Siveter, p.204, pl.7, figs. 8-15.

Holotype. GIG collection No.1521, poorly preserved internal mould of complete dorsal shield; figured Lamont 1949, pl.18, figs.9-12, refigured Siveter 1973, pl.9, figs.12-14.

Type locality. Given by Lamont (1949, p.318) as "Bargany Pond Burn Group (Lower Gala), North side of Hadyard Hill, south-west of Dailly". The rocks on the north side of Hadyard Hill have been termed Drumyork Flags by Cocks & Toghill (1973) of upper Telychian age.

Paratype. RSM 1956.15.54 (formerly Lamont Collection No.33), disarticulated dorsal shield; figured Lamont 1949, pl.18, fig.8, refigured Siveter 1973, pl.7, figs.8,10,11,15. The locality given for this specimen by Lamont (1949, p.318) is "Penkill Group (Lower Gala), Penwhapple gorge, near Penkill Castle".

Description and discussion. See Siveter (1973, p.206).

3. Calymene ?frontosa Lindström, 1885 Pl.15, fig.19.

Material, locality and horizon. From Wood Burn Formation, Locality 21: LRMC 8, external mould of cranidium.

Discussion. A single cranidium differs from other Calymene species in having 3 lateral glabellar lobes, a narrow anterior border which projects higher than the glabella and is distinctly arched anteriorly, a very deep and wide anterior border furrow merging with wide and deep anterior section of axial furrow, and a subconical anterior part of fixed cheek projecting upwards and inwards.

This cranidium is closely related to Calymene frontosa Lindström 1885, from the lower Wenlock of Gotland in the structure of the anterior border and the preglabellar furrow. The posterior border furrow is not as deep as is typical of the Gotland form.

4. Calymenid gen. et sp. indet. Pl.15, figs.21,22.

Material, locality and horizon. From Knockgardner Formation, Locality 24: RCK 8, Pl.15, figs.22a,b, cranidium; YH 2K2, Pl.15, fig.21, free cheek.

Description. Glabella as wide as long, tapering slightly anteriorly, anterior margin transverse. 1L distinct, 1/3 length (exsag.) of glabella, protruding a little abaxially beyond 2L. 1S curving inward and backwards. 2L about ½ size of 1L. 3L small, transverse, ridge-like. Occipital ring 1/5 length (sag.) of glabella. Occipital furrow deep. Fixed cheek not well preserved but with distinct posterior border and posterior border furrow. Internal surface with sparse, large granules. Posterior section of facial suture curving outwards and backwards furthest limit unknown. Lateral border of free cheek wide (tr.). External surface of free cheek with irregularly arranged, unequal sized, granules.

Discussion. Incompleteness of this form (no preglabellar area, no fixed cheek) renders it impossible to assign the form to a genus or species. The narrow (exsag.) posterior border is a characteristic of C. frontosa, from the lower Wenlock of Gotland, but poor preservation of the Knockgardner form precludes further comparison with frontosa.

Family PHACOPIDAE Hawle & Corda, 1847

Subfamily PHACOPINAE Hawle & Corda, 1847

Genus Acernaspis Campbell, 1967

[= Eskaspis, Clarkson, Eldredge & Henry, 1977]

Type species. Original designation: Phacops orestes Billings 1860, p.60; from the Jupiter and Gun River Formations (Llandovery) of Anticosti Island.

Diagnosis. See Campbell (1967, p.32).

Discussion. Clarkson et al. (1977, p.123) proposed Eskaspis as a subgenus of Acernaspis. It is impossible to separate A.(Acernaspis) and A.(Eskaspis) on characters of the dorsal shield. In A.(Acernaspis) the vincular furrow is continuous around the doublure whereas in A.(Eskaspis) subfrontal depressions are present which may, or may not be joined to the vincular notches by a shallow furrow. The arrangement of vincular notches varies in the two subgenera as outlined by Clarkson et al., (Ibid., p.125). Clarkson et al., (Ibid., p.125) saw A.(Eskaspis) as a late Llandovery offshoot of the A.(Acernaspis) stock, which retained most of its primitive features of dorsal cephalic morphology, but had a more advanced ventral morphology. A.(Eskaspis) was compared by Clarkson et al., (1977, p.124) to Murphycops Lespérance, 1968 (p.819), from the White Head Formation (Llandovery), Percé region, Quebec, in view of the similarity of the ventral morphology. Dorsally they are quite distinct as Murphycops has no auxiliary muscle impressions, no palpebral furrow, enlarged basal nodes and a glabella which expands only slightly anteriorly. Ventral morphology alone therefore and particularly the reduction of the vincular furrow anteriorly should not be overemphasised in phacopine classification. The occurrence of morphologically similar ventral enrollment structures in otherwise dorsally dissimilar phacopines argues for their homoeomorphic development. Hence A.(Acernaspis) and A.(Eskaspis) are regarded as congeneric.

The terminology applied to parts of the phacopine cephalon is given in Text-fig.31.

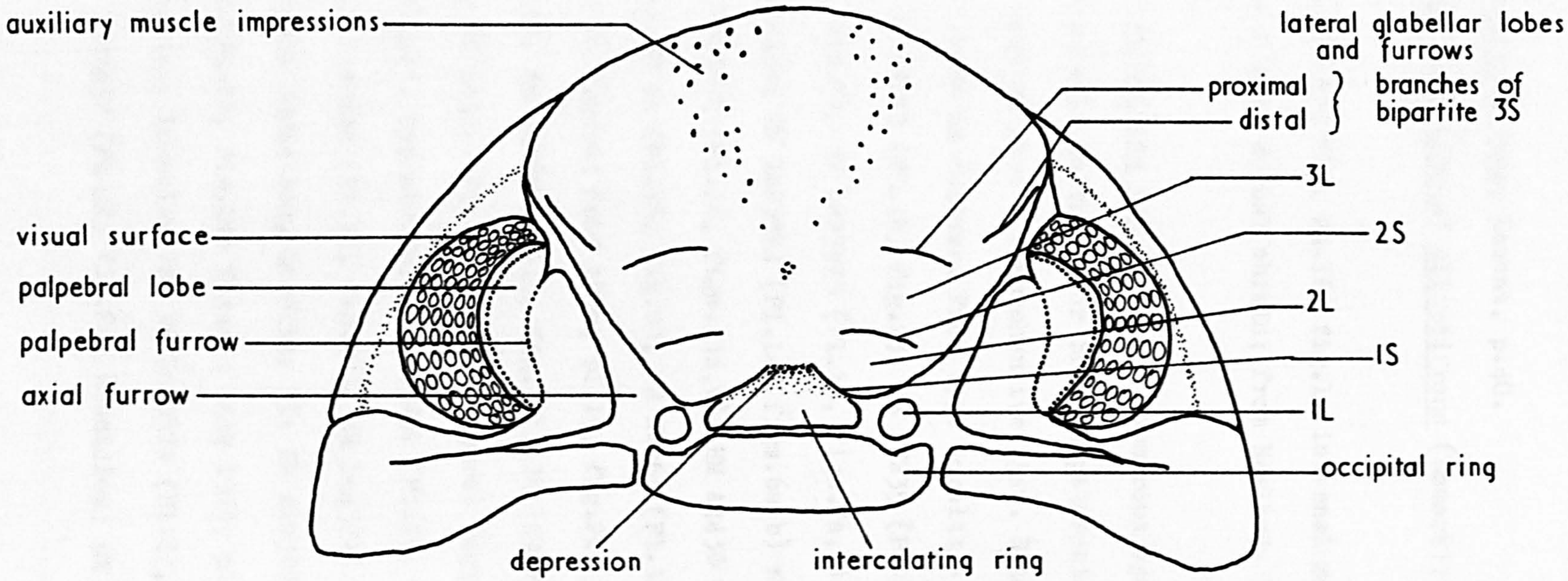
1. Acernaspis superciliexcelsis sp. nov. Pl.16, figs.1-24, Pl.17, figs. 1,2,5; Text-figs.32,33.

Name. Latin 'superciliis', meaning eyebrows and 'excelsus', meaning raised; pertaining to the fanciful resemblance of 2S and 3S to raised eyebrows.

1882 Phacops Stokesii; Lapworth, p.627 [List].

1899 Phacops Stokesii (M, Edw); Peach & Horne, p.532 [List].

v.1906 Phacops (Phacopidella) elegans (Sars & Boeck); Reed, p.154, pl.19, figs.21-23.



TEXT-FIG.31. Terminology applied to parts of the phacopine cephalon.

v.1943 Phacops elliptifrons Sars & Boeck; Begg, p.60, pl.2, fig.9.

v.1950 Phacops (Phacops) elliptifrons Sars & Boeck; Begg, p.368, pl.1, figs.6-12.

1965b Phacops elliptifrons; Lamont, p.40.

1977 Acernaspis (Acernaspis) elliptifrons (Esmark); Clarkson et al., p.124.

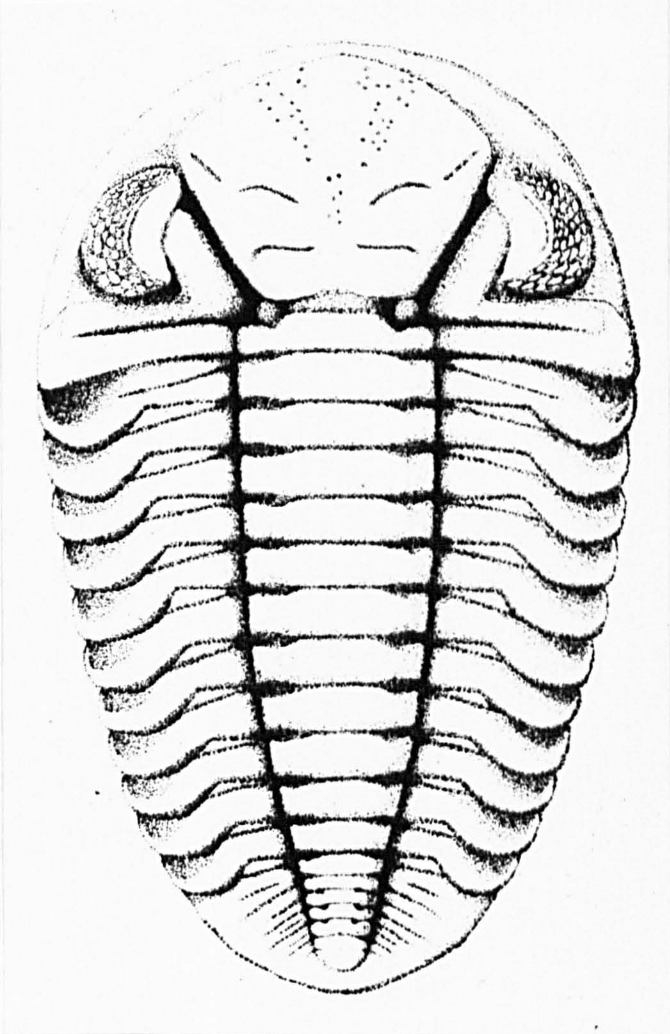
Holotype. BM In23571, Pl.16, fig.1, internal mould and counterpart of slightly disarticulated dorsal shield; from Newlands Formation, Locality 14 (Newlands Farm).

Material, localities and horizons. Numerous specimens belonging to this species are available in the major British palaeontological museums and no attempt is made to give a comprehensive list. Details of specimens figured herein are given as follows. From type locality: BM In43264 (Pl.16, fig.16) cephalon; YH NW272 (Pl.16, fig.2), YH NW235 (Pl.16, figs.3a,b), HM A1004/3 (Pl.16, fig.5), BM In23573 (Pl.16, figs.7a,b) figured Reed 1906, pl.19, fig.22, cranidia; BM In23574 (Pl.16, figs.6a,b) figured Reed 1906, pl.19, fig.23, BM In23578 (Pl.16, figs.14a,b), HM A4430 (Pl.16, fig.17), complete specimens; BU 11 (Pl.16, fig.8), YH NW263 (Pl.16, fig.11), BM In 23572 (Pl.16, fig.20) figured Reed 1906, pl.19, fig.21 , free cheeks; BM In 43234 (Pl.16, fig.9), HM A4408 (Pl.16, fig.10), BM It9121 (Pl.16, fig.12), cephalic doublure; HM A4145 (Pl.16, fig.15) figured Begg, 1950, pl.1, fig.11, YH NW455 (Pl.16, fig.4), hypostomes; BM In43232 (Pl.16, fig.19), HM A5954 (Pl.16, fig.21), BM In43248 (Pl.16, fig.22), BM In43276 (Pl.16, fig.23), pygidia. From Newlands Formation, Locality 11: HM A10308 (Pl.16, fig.13) cranidium; HM A742 (Pl.16, fig.18) figured Begg 1943, pl.2, fig.9, hypostome. From Woodland Formation, Locality 18: BM In23579 (Pl.17, fig.1) incomplete dorsal shield; BM In44457 (Pl.17, fig.2), cranidium; BM In23581 (Pl.17, fig. 5) pygidium.

Diagnosis. A species of Acernaspis with 1S furrows reaching almost to sagittal line. 2S and 3S deeply impressed. Intercalating ring (Burton & Eldredge 1974, p.350) depressed below level of glabella. Small eyes with 16, rarely 17, files with a general lens formula of 345 454 554 443 2. Smaller specimens with genal spines. Vincular furrow with nine notches laterally.

Dimensions of holotype. Total sagittal length of dorsal shield, 27.0mm; sagittal length of cranidium, 8.0mm; width of cephalon at posterior border, 18.0mm; sagittal length of pygidium, 6.3mm; maximum width of pygidium, 12.0mm.

Description. Cephalon, twice as wide as long, anterior margin rounded, posterior margin almost straight. Glabella hardly extruding above level of top of visual surface of eye, only slightly convex in lateral profile, sloping rapidly down to anterior margin, with no preglabellar furrow or preglabellar field. Glabella twice as wide at 1L as long, anterior width of glabella twice width at 1L. Axial furrows deeply impressed diverging at about 60° and widening anteriorly. 1S furrow deep, anteromedially directed at 25° to transverse direction, dying out medially. Proximal limits of 1S joined by very shallow transverse depression delimiting depressed intercalating ring anteriorly. 2S isolated from axial furrow, almost transverse, very slightly bowed anteriorly, proximal extent level with that of 1S, distally extending not as far as 1S; shallowing and lengthening (exsag.) laterally. Proximal branch of bipartite 3S much more curved, adaxial limit more posterior than abaxial limit, slightly longer (exsag.) and shallower than 2S; distal branch of 3S straight, anteriorly directed at 45° to axis dying out before anterolateral corner of glabella. 1L reduced to nodes, distally delimited adaxially by shallow furrow subparallel to axial furrow, not reaching level of surface of anterior glabella region and occipital ring. Occipital ring 6 times wider than long (sag.). Occipital lobes are slight swellings laterally placed. Posterior border expanding laterally to twice adaxial length (exsag.); posterior border furrow transverse almost dying out before genal angle. Fixed cheek greatly inflated between eye and glabella. Palpebral lobe crescentic in outline, horizontal, 1/3 length (exsag.) of cranidium (sag.), extending from 1S to midpoint of distal branch of 3S, divided from inflated cheek by shallow palpebral furrow, and with faint rim. Anterior se-



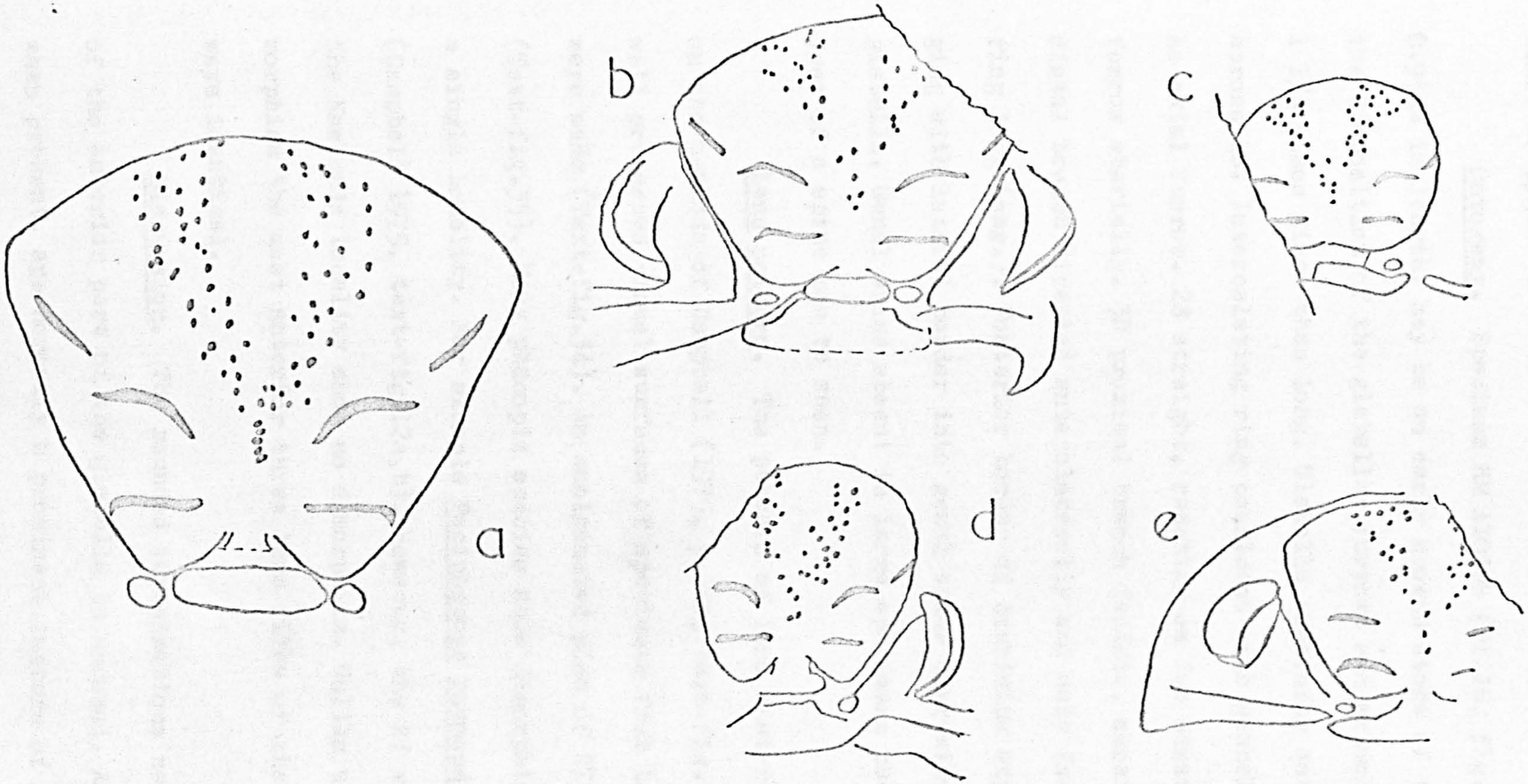
TEXT-FIG.32. Reconstruction of the dorsal shield of Acernaspis superciliexcelsis sp. nov. Normal sagittal length, 27.0mm

ction of facial suture cutting diagonally across axial furrow towards anterolateral margin of glabella; posterior section initially directed posteriorly, for short distance, then transversely outward but slightly posteriorly as cross lateral border. Free cheek subtriangular in outline. Visual surface steeply inclined. Lenses projecting beyond sclera, arranged in 16, rarely 17, dorso-ventral files, decreasing in size upwards, with general lens formula: 345 454 554 544 443 2: maximum per file, 5: total, 65. Lateral border of free cheek wide, gently convex. Whole surface of cephalon, except for furrows and visual surface, covered with very fine, closely spaced granules. Anterior part of glabella with rounded invaginations (Eldredge 1971, p.66) in typical Acernaspis pattern (see Pl.16, figs.1,2; Text-fig.33) but not impressed on internal surface. Cephalic doublure approximately 1/3 glabella length (sag.), narrowing rapidly laterally; hypostomal suture slightly bowed anteriorly. Vincular furrow continuous on whole doublure, deeper laterally with 9 (or 10) oval notches arranged radially. Whole doublural surface with fine, closely packed granules.

Hypostome, subquadrate, as wide as long excluding anterior wings, anterior outline transverse, anterolaterally extended into short broad wing which is 1/3 width and 1/6 length (exsag.) of hypostome. Posterior margin rounded, posterolateral corner truncated. Lateral border very narrow, flat; posterior border longer (sag.). Middle body gently convex, middle furrow indistinct. Macula small, convex, oval, and placed at ½ length of hypostome (exsag.) close to lateral border. Surface sculpture of closely packed granules.

Thorax of 11 segments, the whole tapering slightly posteriorly. Axis, ¼ total width of thorax, greatly convex, tapering posteriorly, 3 times longer than wide. Axial ring approximately 5 times wider (tr.) than long (sag.), flattened for medial ¾ of ring and narrowing laterally. Articulating half ring ½ width (tr.) of axial ring; ring furrow long (sag.) and shallow. Pleura 5 times wider than long (exsag.), parallel-sided and horizontal for adaxial ½, distally flexed down, curving slightly anteriorly and ending bluntly. Pleural furrow directed diagonally posteriorly from anterior adaxial limit of pleura recutting anterior border of pleura again on deflected ½. External surfaces, except for furrows, very finely granulated.

Pygidium straight edged anteriorly, rounded posteriorly, over twice as wide as long. Pygidial axis greatly convex anteriorly, less convex posteriorly; 2/7 width of pygidium at anterior margin, tapering to ⅕ pygidial width posteriorly and terminating bluntly before posterior margin. 8 pygidial rings, first 5 well defined, remainder effaced medially but with distinct depression laterally. Second to sixth rings with projection for median 1/3 of ring anteriorly. Axial furrow well defined, shallowing posteriorly. Pleural field with 4 or 5 pleural ribs directed posteriorly and dying out



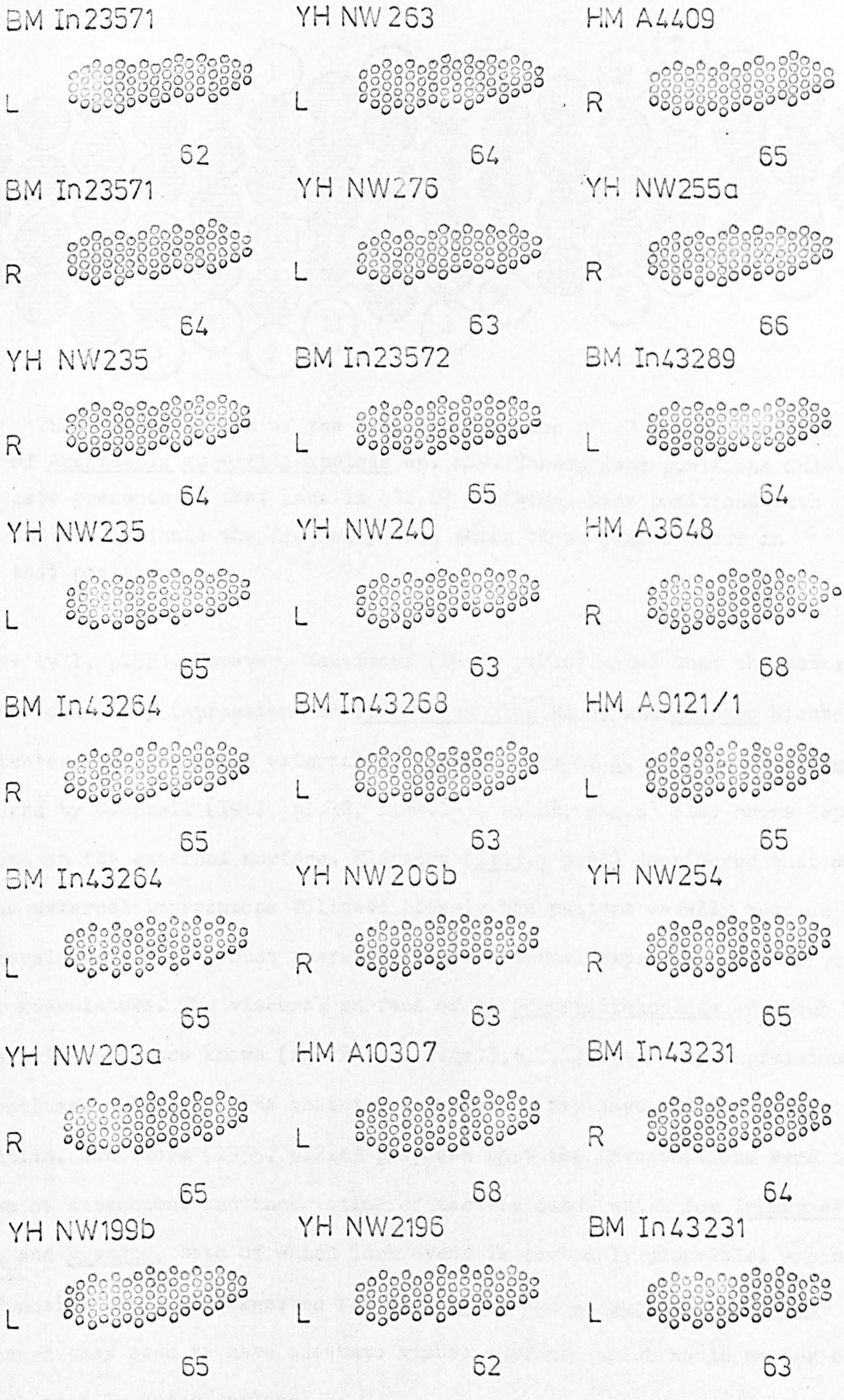
TEXT-FIG.33. Sketches of cranidia of Acernaspis superciliexcelsis sp. nov. showing patterns of the auxiliary muscle impressions. All latex casts of external moulds. a. BM In43246 x6.5; b. YH NW272 x4; c. BM In43223 x2; d. BM In43153 x2; e. YH NW202b x2.

before posterior margin; most anterior pleural rib very long (sag.) and with pleural furrow similarly arranged to those of thorax, remaining pleural ribs decreasing in length (exsag.) posteriorly. Interpleural furrow shallowing posteriorly. Surface, except for furrows, with evenly spaced, fine granules. Pygidial doublure extends to ends of pleural ribs and to posterior limit of pygidial axis.

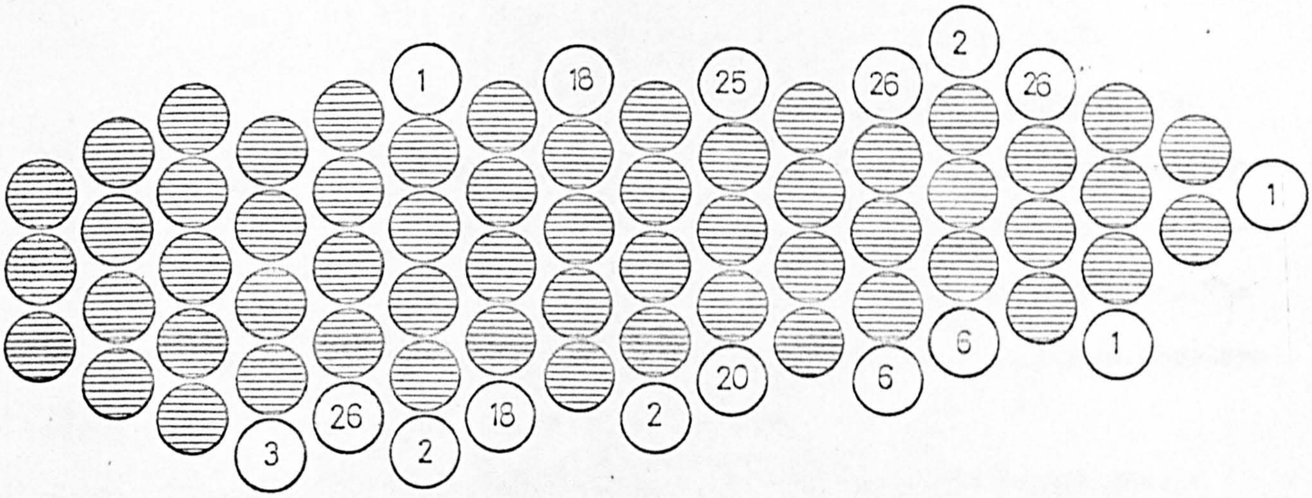
Ontogeny. Specimen HM A10308 (Pl.16, fig.13) from Locality 11 and 0.95mm in length, may be an early growth stage of this species because of the disposition of the glabellar furrows and expanding glabella. Cranidium 1 1/3 times wider than long. Glabella expanding anteriorly to twice width across 1S. Intercalating ring confluent with glabella. 1S straight, as deep as axial furrow. 2S straight, reaching as far adaxially as 1S, touching axial furrow abaxially. 3S proximal branch isolate, straight, shorter than 2S, distal branch directed anterolaterally and only faintly visible. Occipital ring long (sag.). Posterior border of cranidium expanding laterally and merging with lateral border into genal spine approximately 1/3 length (sag.) of glabella. Genal spine absent in large specimens but in small specimens vestiges of a spine can be seen.

Lens pattern. The pattern of lens distribution was studied based on the methods of Campbell (1975, p.186, text-fig.12a,b). Lens plans of 24 well preserved visual surfaces of specimens from Locality 14 (Newlands Farm) were made (Text-fig.34). An amalgamated plan of 27 surfaces was also produced (Text-fig.35). Many phacopid species show dimorphism of lens arrangements at a single locality. For example Paciphacops raymondi Delo shows dimorphism (Campbell 1975, text-fig.12a,b). However, the 27 visual surfaces studied from the Newlands locality show no dimorphism. Unlike the case of Campbell's dimorphism the most anterior three lens files of the Newlands species are always identical.

Discussion. The rounded invaginations seen on the external surface of the anterior part of the glabella is unusual. Auxiliary muscle impressions, when present, are normally a prominent feature of the visceral surface (Eld-



TEXT-FIG.34. Plan of lens distribution of 24 visual surfaces of <u>Acernaspis</u> <u>superciliexcelsis</u> sp. nov. from Locality 14. Left hand file always most anterior. 'L' and 'R' indicate left or right visual surface of specimen. Number in bottom righthand corner of each pattern is the total number of lenses for that surface.



TEXT-FIG.35. Plan of the lens distribution of 27 visual surfaces of Acernaspis superciliexcelsis sp. nov. Shaded lens positions indicate presence of that lens in all 27 surfaces. Lens positions with numbers indicate the frequency with which those lenses occur in that position.

redge 1971, p.53). However, Maksimova (1955, p.214) noted that the pattern of the auxiliary impressions in Trimerocephalus McCoy and Dianops Richter & Richter were expressed externally. The specimen of A. orestes (Billings) figured by Campbell (1967, pl.12, figs.1-3, pl.13, fig.8) also shows depressions on the external surface. Eldredge (Ibid., p.53) considered that as these external impressions followed closely the pattern usually seen on the visceral surface they must therefore be an external expression of the visceral musculature. The visceral surface of A. superciliexcelsis of which many internal moulds are known (eg. Pl.16, figs.3,6,7,14) lack any impressions or calluses. This suggests that the impressions may have had a different function. Maksimova (1955, p.214) proposed that the invaginations were the sites of attachment and innervation of tactile setae which for Trimerocephalus and Dianops, both of which lack eyes, is certainly plausible. A similar function could be suggested for A. orestes and A. superciliexcelsis although they seem to have adequate visual surfaces which would render additional tactile setae useless.

A. superciliexcelsis sp. nov. is most similar to A. orestes (cf. Campbell 1967, pl.12, figs.1-4,19) differing only in the lens formula and in that the glabellar furrows of the Girvan form are longer (tr.).

Lamont (1965, p.40) in comparing his Phacops straitonensis with "Phacops elliptifrons" from Locality 14 (Newlands Farm) [= A. superciliexcelsis] recognized two types of cranidia, one with a rounded outline anteriorly as illustrated by Begg (1950, pl.1, fig.9), and one more angular. The present author refutes the validity of this division as the species displays continuous variation between these two states.

A. superciliexcelsis differs from a form from the Purple Shales (Telychian), Shropshire, assigned to A. elliptifrons (Esmark) by Whittard (1938, p.127, pl.5, figs.9,10) which has a shorter 2S and 3S, a more inflated intercalating ring and about 84 lenses on the visual surface compared with 65 in superciliexcelsis.

2. Acernaspis xynon sp. nov. Pl.17, figs.3,4,6,7,10.

Name. Greek 'xynon' noun in apposition, meaning companion; alluding to its association with A. superciliexcelsis at Woodland Point, Locality 18.

1899 Phacops (Acaste) Downingae (Murch); Peach & Horne, p.542 [List].

v.1906 Phacops (Phacopidella) elegans (Sars & Boeck); Reed, p.154, pl. 19, fig.20.

1906 Phacops (Phacopidella) downingae (Murchison); Ibid., p.156.

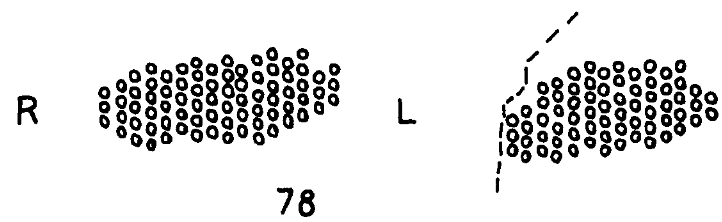
Holotype. BM In44521, Pl.17, figs.6a,b, slightly damaged cranidium; from Woodland Formation, Locality 18 (Woodland Point).

Material, localities and horizons. Specimens belonging to this species are available in the major British palaeontological museums and no attempt is made to give a comprehensive list. Details of material figured herein are as follows. From type locality: BM In44479 (Pl.17, fig.3) cranidium; YH W14 (Pl.17, fig.10) cephalic doublure; BM In47091 (Pl.17, fig.4) BM In23584 (Pl.17, fig.7) figured Reed 1906, pl.19, fig.20, pygidia. The species is also found in the Mulloch Hill Formation, Locality 10.

Diagnosis. Acernaspis species with intercalating ring confluent with glabella and subtriangular in outline. Large eyes with 16 files with general lens formula of 345 655 656 566 553 3. Small genal spine present in all specimens. Vincular furrow with 9 notches. Pygidial axis terminating away from posterior margin.

Dimensions of holotype. Sagittal length of cephalon, 6.5mm; maximum width of cephalon, 12.5mm.

Description and discussion. A. xynon is similar to A. superciliexcelsis but differs in the following respects. 1S is shorter and more oblique, hence giving the intercalating ring a triangular outline. The intercalating ring is confluent with the glabella. The lenses are arranged in 16 dorsoventral files. The general lens formula is 345 655 656 566 553 3, with a maximum of 6 lenses per file and a total of 78 lenses altogether (see Text-fig. 36). Small genal spines are present. The pygidial axis terminates more



TEXT-FIG.36. Lens plan of the visual surfaces of specimen BM In44521, of Acernaspis xynon sp. nov., from Locality 18 (Woodland Point). Left visual surface incomplete.

bluntly and further from the posterior margin. Hypostome is unknown.

The retention of a genal spine in mature specimens of species of Phacopinae is unusual.

3. Acernaspis cf. A. elliptifrons (Esmark, 1833) Pl.17, figs.8,9,11-17.

1851 Phacops Stokesii, Milne-Edw; Salter, p.171, pl.9, figs.2a,b.

1873 Phacops Stokesii Milne Edw; Salter, p.76.

1878 Phacops Stokesii, Milne-Edwards; Nicholson & Etheridge, p.98.

v.1878 Phacops Brongniarti, Portlock; Ibid., p.99, pl.7, fig.2.

1899 Phacops stokesi (M.Edw); Peach & Horne, p.529 [List].

1899 Phacops (Acaste) Downingae (Murch); Peach & Horne, p.529,530 [List].

1906 Phacops (Phacopidella) elegans (Sars & Boeck); Reed, p.154.

non1977 Acernaspis (Acernaspis) elliptifrons (Esmark); Clarkson et al., p.124, text-fig.3a [= A. superciliexcelsis].

Material, localities and horizons. Specimens of this form can be found in the major British palaeontological museums and no attempt is made to give a comprehensive list. Details of material figured herein are as follows. From Mulloch Hill Formation, Locality 8: YH R31 (Pl.17, fig.15a,b), cephalon and thorax; BM In47922 (Pl.17, fig.16), complete specimen; HM A5172 (Pl.17, fig.8) cranidium; YH R130 (Pl.17, fig.11) cephalic doublure; GSM 19232 (Pl.17, fig.13) cranidium with separate pygidium glued on to the same block, possibly figured Salter 1851, pl.9, figs.2a,b; YH R131 (Pl.17, fig.14) free cheek; YH R40 (Pl.17, fig.17) pygidium. From Mulloch Hill Formation, Locality 6: BM In23570 (Pl.17, fig.9) complete specimen; BM In 23568 (Pl.17, fig.12) thorax and pygidium figured Nicholson & Etheridge 1878, pl.7, fig.2.

Description. The form differs from A. superciliexcelsis sp. nov. in the following respects: the glabella is flattened; the anterior margin of the glabella is angular in dorsal outline; 1S does not reach as far across the glabella; the intercalating ring is longer (sag.) and continues the convexity of the glabella; 2S and 3S glabellar furrows narrower (tr.), distal branch of 3S more deeply cut so very distinct on internal moulds; 1L more inflated; cranidial axial furrow widens (tr.) considerably anteriorly; vincular furrow of cephalic doublure very indistinct anteriorly, posterior margin of doublure greatly bowed anteriorly to almost being concentric with anterior margin; lenses arranged in approximately 18 files, general lens formula is 455 566 656 656 554 332; pygidium has narrower and larger (sag.) axis.

Discussion. This form is here compared with A. elliptifrons (Esmark 1833, p.269, pl.7, figs.6,7, refigured Campbell 1967, pl.12, fig.

5) from the Llandovery (6c) of the Oslo region, Norway. The two are virtually identical in the form of the intercalating ring, 1L lobe, glabellar furrows (especially the deep nature of the distal branch of 3S), 'pointed' anterior margin of glabella, and flatness of field of fixed cheek. The eye of the Girvan form is relatively longer (exsag.) than that of _A_. _elliptifrons_. In view of the similarities between the material described and the two known tightly enrolled specimens of _A_. _elliptifrons_ of which the ventral morphology is not known, the Girvan material is compared to that species.

The Girvan material is also similar to the material from the Purple Shales (Telychian) of Shropshire assigned by Whittard (1938, p.127, pl.5, figs.9,10) to _A_. _elliptifrons_ (Esmark). They differ in that the Shropshire form has a more convex glabella, a shorter (tr.) and not so deeply entrenched distal branch of 3S, a more convex outline to the anterior margin of the glabella, and wider and shorter pygidium. It is doubtful if the Shropshire form can be assigned to _A_. _elliptifrons_ as it has a relatively longer eye, a less inflated intercalating ring and shallower distal 3S branch.

Temple (1970, p.68, pl.18, figs.10-12,21) referred some poorly preserved material from Meifod (early Llandovery) to _A_. _elliptifrons_ s.l. However, the form is too badly preserved to make a comparison.

Acernaspis sp. of Temple (1975, p.156, pl.27, figs.1-4) from the early Llandovery of Llandysilio and Haverfordwest has similar cranidial characters to those of the Girvan form. However, the lens formula differs and the pygidial axis of the Welsh form terminates more anteriorly and is wider.

4. _Acernaspis_ sp. A Pl.17, figs.18-23, Pl.18, figs.1,2,5.

?1899 _Phacops stokesi_ (M. Edw); Peach & Horne, p.536 [List].

Material, localities and horizons. The majority of specimens belonging to this species are from the writer's own collection and no attempt is made to give a comprehensive list. Details of material figured herein are as follows. From Lower Camregan Grits, Locality 19: YH C19 (Pl.17, fig. 18), YH C98 (Pl.18, fig.5), cranidia; YH C17 (Pl.17, fig.19), YH C33 (Pl.17, fig.22), cephalic doublures. From Lower Camregan Grits, Locality 16: LRMC 1 (Pl.17, fig.21) cranidium; LRMC 14 (Pl.17, fig.20), pygidium. From Wood Burn Formation, Locality 22: BM In23587 (Pl.17, fig.23) pygidium; BM In46622 (Pl.18, fig.1) cranidium; GSM 4274 (Pl.18, fig.2) thorax and pygidium.

Description and discussion. A species of Acernaspis differing from A. superciliexcelsis in that the glabella is not greatly inflated, the anterior margin of the glabella is more pointed, the intercalating ring is almost confluent with the glabella, 3S proximal branch is virtually parallel with 2S, 1S does not reach as far adaxially, and the vincular notches are not well developed.

In many ways this material is more similar to A. cf. A. elliptifrons from the Mulloch Hill Formation differing only in that the vincular furrow of the cephalic doublure is more deeply incised, the 3S distal branch is not so deeply cut, and the intercalating ring is depressed below the level of the glabella.

Acernaspis sp. A includes material from three localities which might not be conspecific. The material from Locality 19 (Camregan Wood), although comparatively plentiful is preserved in a medium to coarse grained sandstone and is virtually only known from internal moulds. Locality 16 (Craigfin) material is also poorly preserved in a sandstone. Locality 22 (Penkill) material is a little better preserved but there are few specimens.

5. Acernaspis woodburnensis Clarkson et al., 1977 Pl.18, figs.3,4,6-8.

1899 Phacops stokesi (M.-Edw); Peach & Horne, p.538 [List].

1906 Phacops elegans Sars & Boeck; Reed, p.155.

v*1977 Acernaspis (Eskaspis) woodburnensis n. sp.; Clarkson et al., p.132, pl.19, figs.9,11-13; text-fig.5a,b.

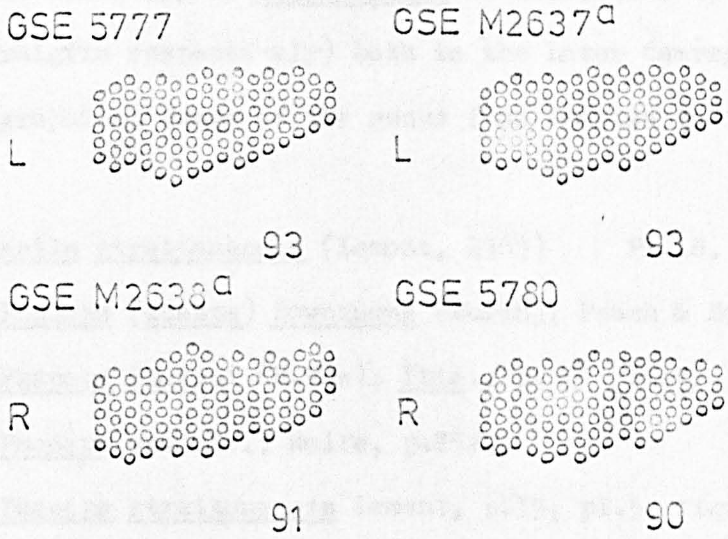
Holotype. GSE 5777, Pl.18, fig.7, internal mould of complete dorsal shield; figured Clarkson et al., pl.19, fig.11; from Wood Burn Formation, Locality 21 (Bargany Pond Burn).

Paratypes. See Clarkson et al., (1977, p.132).

Material, localities and horizons. This species is represented in the major British palaeontological museums and no attempt is made to give a comprehensive list of specimens. Details of material figured herein is given as follows. From type locality: GSE 5780 (Pl.18, figs.4a,b) figured Clarkson et al., 1977, pl.19, figs.12,13, complete specimen; BM In23565 (Pl.18, figs.8a,b) figured Reed 1906, pl.19, fig.19, cranidium; YH B27 (Pl.18, fig. 3) free cheek; GSE JS17995 (Pl.18, fig.6) pygidium. This species is also found at Wood Burn Formation, Locality 20.

Diagnosis. As Clarkson et al.,(1977, p.132).

Discussion. This species is similar to Acernaspis sufferta (Lamont, 1947) from the North Esk Inlier (Clarkson et al., 1977, p.125, pl.18, figs. 1-9, pl.19, figs.1-7; text-fig. 2a,f, 3a,b, 4a,c) except for the ventral



TEXT-FIG.37. Acernaspis woodburnensis Clarkson et al., 1977.
Lens plans for four visual surfaces of specimens from Locality 21.

cephalic doublure. The Girvan form has very shallow vincular furrows joining the subfrontal depressions and also vincular notches. These are lacking in A. sufferta.

Family PTERYGOMETOPIDAE Reed, 1905

Genus Podowrinella Clarkson et al., 1977

Type species. Original designation: Phacops straitonensis Lamont, 1965; from Knockgardner Formation (?Wenlock) of the Blair-Straiton district, Girvan; Ree Burn Formation (?Telychian), Hagshaw Hills; and Deerhope Formation (Telychian), North Esk Inlier, Pentland Hills.

Diagnosis. See Clarkson et al., 1977, p.134.

Discussion. Podowrinella shows characters of both the Pterygometopidae and Phacopidae and these are outlined by Clarkson et al. (1977, p.139). These authors were unable to finally decide on the taxonomic position of Podowrinella but agreed that the occurrence of an amalgamation of characters from the two families in Podowrinella emphasized Eldredge's 1971 suggestion of a very close relationship between them.

The discovery of Podowrinella at Localities 19 and 16 (Camregan Wood and Craigfin respectively) both in the Lower Camregan Grits, increases the stratigraphical range of the genus from Fronian to ?Wenlock.

1. Podowrinella straitonensis (Lamont, 1965) Pl.18, figs.9-13.

1899 Phacops (Acaste) Downingae (Murch); Peach & Horne, p.550 [List].

1899 Phacops Stokesi (M.Edw); Ibid., p.550 [List].

1962 Phacops sp. nov.; Rolfe, p.252.

v*1965 Phacops straitonensis Lamont, p.39, pl.5, fig.5.

1973 Phacops straitonensis; Rolfe, p.109.

v.1977 Podowrinella straitonensis (Lamont, 1965); Clarkson et al., p.134, pl.20, figs.1-14, text-figs.6a-h.

Neotype. Designated by Clarkson et al.: BU 1900a,b, cranidium, figured Lamont 1965, pl.5, fig.5, refigured Clarkson et al., 1977, pl.20, fig.1; from Rolfe's locality 31/48 in unpublished thesis, University of Birmingham, 1960, Ree Burn Formation, Hagshaw Hills.

Material, locality and horizon. This species is known in the Girvan area from the Knockgardner Formation, Locality 24, where it is well represented. Details of material figured herein are as follows. From

Knockgardner Formation, Locality 24: RCK 19 (Pl.18, fig.10), RCK 12 (Pl.18, fig.11), cranidia; RCK 2 (Pl.18, figs.9a,b) free cheek; YH 3K3 (Pl.18, figs. 12a,b), YH 1K26 (Pl.18, fig.13), pygidia.

Description. See Clarkson et al. (1977, p.136).

Discussion. Clarkson et al. emphasized that in P. straitonensis 1S is connected to the proximal 3S branch, a feature common in the Pterygometopidae. However, the connection is not as pronounced in all specimens of P. straitonensis as Clarkson et al. imply. On the majority of specimens the longitudinal furrow is absent or very shallow.

2. Podowrinella sp. Pl.18, figs.14,15.

Material, localities and horizons. From Lower Camregan Grits, Locality 19: YH C107 (Pl.18, figs.14a-d) cephalon and part of doublure. From Lower Camregan Grits, Locality 16: LRMC 2 (Pl.18, fig.15) cranidium.

Description. Cephalic outline approximately triangular. Glabella widest (tr.) across anterolateral corners approximately as wide as long, rounded in outline anteriorly, sloping steeply down to anterior border. Intercalating ring longer medially, shortening (exsag.) laterally, level with glabella. 1L reduced to nodes laterally. 2L subtriangular in outline longest (exsag.) laterally. 1S deeply incised laterally recurved anteriorly adaxially, adaxial limits of 1S furrows joined by very shallow transverse furrow delimiting intercalating ring posteriorly. 2S straight, transverse, shallower than 1S not confluent with axial furrow. 3S proximally comma shaped, distally straight but anterolaterally directed, extreme lateral limit unknown. Axial furrow deep and wide diverging abaxially at angle of 30° to sagittal line reflected immediately anterior to palpebral lobe merging with anterior and lateral cephalic border furrows. Course of anterior section of facial suture unknown but anteriorly meeting in distinct point medially, delimiting small, triangular preglabellar field. Occipital ring of equal length throughout. Occipital furrow narrow and straight. Posterior border and furrow, and lateral border and furrow unknown. Visual surface almost vertical, number of files and lenses unknown. Eye approximately ½ length (exsag.) of glabella (sag.). Palpebral lobe and area not well preserved. Cephalic doublure produced anteriorly into "spatulate process" (Clarkson _et al._, 1977, p.138). Spatulate process bounded distally by deep broad grooves traversing doublure and inclined anteriorly adaxially. Grooves continuous laterally, becoming shallower and dorsal where converging at midline. Auxiliary muscle impression pattern and details of cephalic sculpture not preserved.

Discussion. Because of the poor preservation of material this form cannot be assigned to a species. It can, however, be referred to _Podowrinella_ since specimen YH C107 shows clearly the characteristic vincular furrow and specimen LRMC 2 shows the complete 3S furrow with a hint of a shallow furrow joining the proximal limits of 3S to 1S.

Family LICHIDAE Hawle & Corda, 1847

Diagnosis. See Tripp (_in_ Moore 1959, p.O495)

Discussion. Work on lichid ontogeny (Chatterton, 1971; Temple 1969, 1972) has shown that the 'bicomposite lobes' of lichids are not formed by the joining of 2L and 3L as described by Reed (1902, p.66). They arise from the forward extension, in ontogeny, along the axial furrows of rudimentary swellings which originate opposite 2L. The term bullar lobe has been proposed by Temple (1972, p.374) for these swellings and is accepted here.

Subfamily LICHINAE Hawle & Corda, 1847

Diagnosis. See Tripp (_in_ Moore 1959, p.O496).

Genus _Lichas_ Dalman, 1827

Type species. Original designation; _Entomostracites laciniatus_ Wahlenberg 1818, p.34, pl.2, fig.2; from Dalmanitina Beds, Ashgill Series, of Bestorp, Mösseberg, Sweden.

Discussion. For diagnosis and list of other species see Tripp (1958, p.575; _in_ Moore 1959, p.O496)

<u>Lichas silvestris</u> Reed, 1925   Pl.19, figs.1-7.

v.1906 <u>Lichas</u> (<u>Metopolichas</u>) aff. <u>marginatus</u> Lindström, 1885; Reed, p.104, pl.14, figs.15,16.

v*1925 <u>Lichas</u> (<u>Autolichas</u>) <u>silvestris</u> Reed, p.67, pl.2, fig.1

1925 <u>Autolichas marginatus</u> Lindström; <u>Ibid</u>., p.69.

1931a <u>Lichas</u> (<u>Autolichas</u>) <u>silvestris</u>, Reed; Reed, p.18.

1935 <u>Lichas</u> (<u>Metopolichas</u>) <u>marginatus</u> Lindström; Reed, p.35.

v.1936 <u>Trimerolichas marginatus</u> Lindström; Phleger, p.604, fig.15.

1938 <u>Lichas</u> aff. <u>marginatus</u> Lindström; Whittard, p.115.

v.1957 <u>Lichas</u> sp.; Tripp, text-fig.4F,5G.

1958 <u>Lichas silvestris</u> Reed, 1925; Tripp, p.575 /List/.

<u>Holotype</u>. BM In36954, Pl.19, figs.7a-c, internal mould of pygidium with half of counterpart; figured Reed 1925, pl.2, fig.1; from Mulloch Hill Formation, Locality 9.

<u>Material, localities and horizons</u>. From type locality: BM In22729 pygidium. From Woodland Formation, Locality 18: BM In22798 (Pl.19, fig.3) figured Reed 1906, pl.14, fig.16 and Tripp 1957, text-fig.4F, hypostome; BM In22797 (Pl.19, figs.1a,b) figured Reed 1906, pl.14, fig.15, Phleger 1936, text-fig.15 and Tripp 1957, text-fig.5G, BM In44514 (Pl.19, fig.2), YH WQ1, BM In44518, cranidia. From Mulloch Hill Formation, Locality 10: YH G11 (Pl. 19, fig.6) thoracic segment; YH G25, YH G54 (Pl.19, fig.4), cranidia; HM A 9108 (Pl.19, fig.5) pygidium.

<u>Diagnosis</u>. Cranidium gently convex. Frontomedian lobe narrow (tr.); bullar lobe elongate and not delimited posteriorly. Axial furrow reaching occipital furrow. Occipital lobe and anterior border well developed. Cranidial sculpture of irregularly scattered granules of subequal size. Hypostome with deeply incised middle furrow; posterior margin distinctly indented; middle body pitted, lateral border with strong terrace ridges exsagittally aligned. Pygidium slightly longer than wide. First and second pairs of pleurae terminating in abaxially directed free tips. Third pair of pleurae merge with postaxial ridge. Sagittal line of pygidium carinate. Sculpture

similar to that of cranidium but with more numerous and larger granules.

<u>Dimensions of holotype</u>. Sagittal length of pygidium, 23.0mm; maximum pygidial width, 22.0mm.

<u>Description</u>. Cranidium approximately $1\frac{1}{4}$ times wider posteriorly than long. Frontomedian lobe narrowest ($\frac{1}{8}$ cranidial width) at a point $\frac{3}{4}$ length from its anterior extent; anteriorly expanding to become as wide (tr.) as occipital ring; posterior $\frac{1}{4}$ of length expanding backwards to $\frac{1}{4}$ width (tr.) of posterior border. Longitudinal furrow deep, not reaching occipital or axial furrows, dying out exsagittally opposite adaxial tip of occipital lobe. Occipital ring 5 times wider than long, narrowing (exsag.) laterally. Occipital furrow as deep as longitudinal furrow. Occipital lobe oval in outline, twice as wide (tr.) as long (sag.), transverse. Bullar lobe convex, about $\frac{1}{2}$ cranidial length (exsag.), lying at 30° to sagittal line, ovate in outline, pointed anteriorly, undefined posteriorly, merging into short (exsag.) 1L. Fixed cheek subcrescentic in outline. Axial furrow distinct, reaching occipital furrow at abaxial end of occipital lobe. Palpebral lobe with crescentic outline, $\frac{1}{4}$ cranidial length. Anterior border of cranidium about $\frac{1}{2}$ length (sag.) of occipital ring, flat, curving posteriorly. Anterior border furrow narrow and shallow. Anterior section of facial suture curving immediately abaxially from palpebral lobe, diverging in straight line adaxially to opposite junction of longitudinal and axial furrows and then turns adaxially again to cut anterior border opposite lateral limit of bullar lobe. Posterior path of facial suture not well preserved running subtransversely for about $\frac{1}{2}$ width (tr.) of occipital ring then cuts posterior border. Posterior border a little shorter (exsag.) than occipital ring. All surfaces, excluding furrows, irregularly granulated; furrows with no surface sculpture.

Free cheek unknown.

Middle body of hypostome 1 1/5 times longer (sag.) than wide (tr.) width taken across posterior limit of middle furrow; rounded anteriorly, subparallel-sided and with transverse posterior limit; anterior lobe of middle body expanding rapidly forwards. Middle furrow directed backwards at about 45° to axial line, branching posteriorly, anterior furrow dying out before axial line, posterior furrow lying exsagittally and dying out almost immediately. Anterior wing not preserved. Lateral furrow wide and deep at end of middle furrow, narrowing and shallowing posteriorly, maximum lateral distance from axial line opposite posterior end of middle furrow, curving adaxially, merging with posterior border furrow. Posterior border furrow very faint, shallow and transverse. Lateral border narrowest (tr.) anteriorly, widening and flattening posteriorly. Posterior border merging with lateral border, with long and wide median notch. Middle body pitted and lateral border with coarse striations subparallel to edge of border, no other sculpture visible because of poor preservation.

Only internal mould of one incomplete thoracic segment known. Axial ring gently convex, almost rectangular in outline. Thoracic pleura approximately 7 times wider than long, transverse for most of width, produced into very short backwardly pointing spine. Pleural furrow deep adaxially, shallowing abaxially, running diagonally backwards across pleura. Internal mould of segment with randomly arranged and irregularly sized granules

Pygidium fractionally longer than wide. Axis approximately 1/3 length of pygidium and 1/3 its width at anterior border. Axis anteriorly with well defined axial ring bounded by distinct furrow; second axial ring same size as first, bounded by faint furrow; third axial ring barely distinguishable. Axis passing unbroken into postaxial ridge which gradually expands towards posterior border terminating as a blunt tip posteriorly, merging with third lateral pleura. Axis and postaxial ridge carinate sagittally. First lateral pleura longest (exsag.) at fulcrum, anterior margin turning through 90°, posterior border gently curving posteriorly towards free tip. Second lateral pleura similar to first except free tip points slightly more posteriorly. Third lateral pleura wider than first or second, straight, incompletely marked off from postaxial ridge posteriorly, no free tip. Pleural furrows distinct, first and second approximately parallel to posterior edges of of lateral pleura, third parallel to second. All surfaces with irregularly arranged fine and coarse granules.

Discussion. This form is assigned to Lichas for the following reasons. The longitudinal furrow does not reach the axial or occipital furrow and the occipital lobe is well developed. The hypostome has a strongly indented posterior margin and its middle body is undefined posteriorly. The pygidium has a flaring axis and unindented posterior margin. All these features are characteristic of Lichas.

Reed (1906, p.104, pl.14, figs.15,16) assigned a single cranidium from Locality 18 (Woodland Point) to Lichas (Metopolichas) aff. marginatus Lindström (see Lindström 1885, p.58, pl.14, figs.8,9). Reed noted that the Woodland Point specimen differed in having a longer bullar lobe and in possessing an occipital lobe (sic Lindström's figures clearly show an occipital lobe). The present author has not seen Lindström's material but his illustrations show that his species differs from the Girvan form in that the longitudinal furrow reaches the occipital furrow, the axial furrow reaches the abaxial limit of the occipital lobe, the anterior section of the facial suture cuts the anterior border further from the sagittal line, and the granules of the surface sculpture are coarser and fewer in number. Reed (Ibid., p.106) also noted the similarity of the Woodland Point cranidium to Lichas affinis Angelin (1854, p.69, pl.38, fig.4) especially in respect of the longitudinal furrow not reaching the occipital furrow. Indeed, the Woodland Point form resembles L. affinis more closely than it does L. marginatus, but differs from the former by having a smaller occipital lobe and a longer longitudinal furrow.

Reed (1923, p.456) erected Autolichas with L. affinis as the type species. Apparently, Reed (1925, p.69) then considered the Woodland Point cranidium closer to L. affinis for he referred the cranidium to Autolichas, without comment. But Reed (1935, p.35) compared the Woodland Point cranidium with Lichas (Metopolichas) congruens Reed 1935, from the Drummock Group, (Ashgill Series), South Thraive, Girvan, referring the former cranidium again to Metopolichas with no mention of the 1925 change to Autolichas.

Phleger (1936, p.604) erected Trimerolichas with L. marginatus as the type species. To illustrate this new genus Phleger (Ibid., text-fig.15) took an outline from Reed's figure (1906, pl.14, fig.15) of the Woodland Point cranidium. Whittard (1938, p.115) doubted the validity of Trimerolichas as the wide anterior border was used as an important generic character. Also Whittard considered that confusion could arise because of the uncertainty that Lindström's type and the Woodland Point specimen were conspecific. Whittard thought that the Woodland Point form seemed closely related to L. marginatus and so included it in Lichas ss.

Tripp (1957, p.114) synonymised Trimerolichas with Arctinurus Castelnau 1843. However, to illustrate Lichas (Tripp 1957, text-figs.4F,5G) he used outlines of the Woodland Point cranidium and a hypostome, also from Woodland Point,from Reed (1906, pl.14, figs.15,16). He acknowledged that the hypostome was formerly referable to Trimerolichas but did not do so for the cranidium.

Whittard (1938, p.115) considered the Woodland Point cranidium practically identical with a cranidium which he assigned to L. marginatus from Shropshire. Reed (1906, p.105) had stated that the fourth lateral lobes were almost obsolete on the Woodland Point cranidium, but Whittard considered that Reed's figure of the specimen (Reed 1906, pl.14, fig.15) showed that they had entirely disappeared. The Woodland Point cranidium does show a small 1L lobe on the internal mould and the external mould shows it more clearly. L. marginatus of Whittard, from the Purple Shales (Telychian) of Shropshire, is similar to the Girvan form but with the lack of a large sample from either area it is difficult to make an adequate comparison.

L. silvestris is similar to L. laciniatus (Wahlenberg 1821) but differs in that the whole dorsal shield is narrower (tr.) and longer (sag.).

Cocks & Price (1975, pl.82, figs.1,2) compare lichid material to L. laciniatus from the St. Martin's Cemetry horizon, Portfield Formation (Ashgill), Haverfordwest. However, the present author considers that the

Haverfordwest form compares more closely with L. silvestris. The Haverfordwest specimens are much narrower than L. laciniatus, especially in the cranidium, but not as narrow as the Girvan form. The Haverfordwest pygidium resembles the Girvan pygidium more than L. laciniatus by being narrower and longer, being carinate and having a more pointed posterior border.

Genus Dicranopeltis Hawle & Corda, 1847

Type species. Subsequent designation Reed 1901, p.71; Lichas scabra Beyrich 1845, p.28, fig.16; from the Liteň Formation (Wenlock) of Svatý Jan pod Skalou, Czechoslovakia.

Discussion. For diagnosis and list of other species see Tripp (1958, p.575; in Moore 1959, p.0496).

Dicranopeltis sp. Pl.19, figs.8-11.

Material, localities and horizons. From Newlands Formation, Locality 14: BM In43155 (Pl.19, fig.8), YH NW95 (Pl.19, fig.10), YH NW94, cranidia. From Newlands Formation, Locality 11: HM A8948 (Pl.19, fig.11), cranidium. From Woodland Formation, Locality 18: BM In22792 (Pl.19, fig.9), YH WB9, cranidia.

Description. Cranidium almost twice as wide as long. Frontomedian lobe narrowest opposite base of bullar lobe, 1/3 width (tr.) of occipital ring, expanding anteriorly to twice this width. Longitudinal furrow distinct between bullar and frontomedian lobe but only very faintly visible between latter and 1L. Occipital furrow distinct. Occipital ring $\frac{1}{8}$ length (sag.) of cranidium narrowing (exsag.) laterally to accommodate occipital lobe. Occipital lobe small, triangular in outline, approximately $\frac{1}{4}$ width (tr.) of occipital ring. Axial furrow deep opposite bullar lobe shallowing slightly opposite 1L. Bullar lobe, circumscribed, over $\frac{1}{3}$ cranidial length, rounded anteriorly, pointed posteriorly, with slight depression at midlength. 1L oblong in outline, wider than long, merging with frontomedian lobe. Fixed cheek convex, outline unknown. All convex surfaces with large and small granules randomly arranged.

Discussion. The circumscribed bullar lobes and ill-defined furrows connecting the lateral furrows with the occipital furrow indicate that the cranidia belong to *Dicranopeltis*.

The Girvan specimens differ from the lectotype of *D. salteri* Fletcher 1850 (specimen SM A10261, from the Much Wenlock Limestone Formation, (*lundgreni* Zone), Dudley, West Midlands Metropolitan County) in being shorter and wider, in having a frontomedian lobe which is narrower and expands more rapidly anteriorly, and in having coarser granulation. The granules on the frontomedian lobe of *D. salteri* are regularly arranged with the pattern of the larger granules standing out very clearly. Large and small granules are scattered all over the surface of the Girvan form but it is possible to pick out larger granules that appear to follow the same pattern as those of *D. salteri*.

Two very small cranidia, HM A8948 and YH NW95, here assigned to *Dicranopeltis* could be considered to have ceratargine affinities because of the posteriorly rounded and anteriorly indistinct occipital lobe. These specimens are internal moulds of immature individuals but the shape of the frontomedian lobe and the pronounced pointed posterior margin of the bullar lobe definitely indicate that they belong to *Dicranopeltis*. The immature specimen YH NW95 shows a well defined row of granules adaxial to the axial furrow on the frontomedian lobe, reminiscent of the arrangement of granules on *D. salteri*.

Subfamily HOMOLICHINAE Phleger, 1936

Genus *Platylichas* Gürich, 1901

Type species. Original designation; *Lichas margaritifer* Nieszkowski 1857, p.568, pl.1, fig.15; from the Porkuni Limestone (Ordovician), Estonia.

Discussion. For diagnosis and list of other species see Tripp

(1958, p.576; in Moore 1959, p.0498).

1. Platylichas scoticus (Reed, 1906) Pl.19, figs.12-15, Pl.20, figs. 1-6,8.

1873 Lichas bulbiceps? Salter & Phillips; Salter, p.77 [List].

v.1878 Lichas Grayii, Fletcher (?); Nicholson & Etheridge, p.134, pl.9 figs.11,12.

v.1878 Lichas Barrandei Fletcher (?); Ibid., p.132, pl.9, fig.8.

v.1906 Lichas (Platylichas) grayi, Fletcher, 1850, var. nov. scoticus; Reed, p.100, pl.14, figs.5-9.

v.1906 Lichas (Metopolichas) bulbiceps, Phillips (?), 1873, var.; Reed, p.104, pl.14, fig.14.

v.1906 Lichas (Platylichas) grayi, Fletcher, var. ind.; Reed, p.167, pl. 20, fig.12.

1925 Platylichas Grayi FLETCH var. scoticus REED; Warburg, p.283,286.

1931a Lichas (Platylichas) grayi, Fletcher, var. scoticus, Reed; Reed, p.17.

1938 Platylichas grayi var. scoticus Reed 1906; Whittard, p.114.

1958 Platylichas scoticus (Reed, 1906); Tripp, p.576 [List].

Lectotype. Selected herein; BM In22726, Pl.19, figs.12a-c, internal mould of cranidium; figured Nicholson & Etheridge 1878, pl.9, fig.11,12, refigured Reed 1906, pl.14, figs.6,6a; from Mulloch Hill Formation, Locality 9.

Paralectotypes. From type locality: BM In22725, Pl.19, figs.13a,b, figured Reed 1906, pl.14, figs.5,5a, pygidium. From Mulloch Hill Formation, Locality 8: BM In22727, Pl.20, fig.3, figured Reed 1906, pl.14, fig.7, hypostome; BM In22738, Pl.20, figs.1a-c, figured Reed 1906, pl.20, fig.12, cranidium. From Mulloch Hill Formation, Locality 6: BM In22732, Pl.20, fig. 5, figured Reed 1906, pl.14, fig.9, pygidium. From Mulloch Hill Formation, Mulloch Hill (Localities 1-7): GSM 16192, Pl.19, fig.15, figured Reed, 1906, pl.14, fig.8, and Nicholson & Etheridge 1878, pl.9, fig.8, pygidium; BM In

22794, Pl.20, fig.4, figured Reed 1906, pl.14, fig.14, cranidium.

Other material. From Mulloch Hill Formation, Locality 6: SM A34884 (Pl.20, fig.2), cranidium. From Mulloch Hill Formation, Locality 9: BM In 22720, In22730,1, In22739-41, cranidia; Bm In22729, In42681 (Pl.20, fig.6), In37074, pygidia; HM A3371, hypostome. From Woodland Formation, Locality 18: BM In22736, cranidium; BM In22735 (Pl.20, fig.8) hypostome; BM In47921, YH WB14, pygidia. From Mulloch Hill Formation, Locality 7: HM A10312 (Pl.19, fig.14) cranidium. From Newlands Formation, Locality 14: BM In22733, cranidium; BM In42695, pygidium.

Diagnosis. Cranidium greatly inflated, deflected through 90°. Bullar lobes circumscribed. 1L fused with free cheek. Anterior border narrow. Hypostome with moderately convex middle body, long posterior border deeply indented, middle body coarsely pitted and lateral border with striations. Pygidium 1½ times wider than long, axis with 3 rings anteriorly, pleurae with free points. Cranidial and pygidial surfaces with coarse granules.

Dimensions of lectotype. Cranidial sagittal circumferal length, 9.0mm; projected cranidial maximum width, 11.0mm; width across glabella at base of bullar lobes, 2.1mm.

Description. Cranidium 1 1/3 times wider (tr.) than long (sag.). Frontomedian lobe narrowest just anterior of junction of longitudinal furrow and axial furrow where 1/6 width of cranidium, expanding anteriorly to 2½ times its narrowest width. Longitudinal furrow distinct, extending from anterior border to occipital ring. Occipital furrow straight medially. Occipital ring 1/10 length (sag.) of cranidium, shortening (exsag.) laterally to accommodate occipital lobe. Occipital lobe subtriangular in outline, approximately ¼ width of occipital ring, narrow end adaxial, expanding abaxially. Bullar lobe circumscribed, 1/3 cranidial length (sag.) slightly pointed posteriorly and anteriorly, oblique with posterior adaxial. Axis furrow distinct, joining longitudinal furrow behind bullar lobe. Anterior border very narrow (sag.). Posterior border ¼ width (tr.) of cranidium, narrow (exsag.). Posterior border furrow increasing slightly in length (exsag.) abaxially.

Palpebral lobe not visible. Anterior section of facial suture not clearly defined but appears to run exsagittally forward from opposite anterior $\frac{1}{2}$ of bullar lobe. Posterior section of facial suture running transversely before cutting posterior border almost at right angles. All convex surfaces granulated, furrows without sculpture.

Free cheek unknown.

Middle body of hypostome moderately convex, $1\frac{3}{4}$ times wider than long, posteriorly tapering to 2/3 anterior width, anterior lobe $\frac{3}{4}$ length of middle body. Anterior margin absent. Lateral border expands rapidly posteriorly to opposite posterior border furrow of middle body. Posterior border broad, $\frac{1}{2}$ length of longest part of middle body, sagittally indented. Sculpture not always preserved in detail but middle body coarsely pitted and lateral border with striations parallel to lateral margin.

Thorax unknown.

Pygidium $1\frac{1}{2}$ times wider than long. Axis, approximately $\frac{1}{2}$ pygidial length (sag.) and 1/3 its anterior width, greatly convex, tapering slightly posteriorly for $\frac{1}{2}$ of its length, parallel-sided for remaining $\frac{1}{2}$. Anterior $\frac{1}{2}$ of axis with 3 axial rings bounded by well defined furrows; first and second furrows deeper than third. Postaxial ridge tapering rapidly for $\frac{1}{2}$ its length then expands a little before reaching posterior border. First lateral pleura expanding rapidly to fulcrum. Anterior border turning through 45°, posterior border straight, narrowing beyond fulcrum to blunt free tip. Second lateral pleura longer (exsag.) than first, straight, narrowing beyond fulcrum to blunt free tip. Third lateral pleura longer (exsag.) than second, incompletely marked off from postaxial ridge posteriorly, with no free tip laterally, but with small indentation of posterior margin sagittally. Pleural furrows distinct; first and second approximately parallel with posterior edges of lateral pleura, third subparallel to second. All pygidial surfaces with irregularly arranged large and small granules.

Discussion. This species is placed in Platylichas because the axial furrow joins the longitudinal furrow anterior to the occipital furrow, and the pygidium has 3 pairs of furrowed pleurae ending in free points.

P. scoticus is similar to P. grayii Fletcher 1850, from the Wenlock of Britain and Gotland, but differs in that 1L is longer (exsag.), the posteroir limit of the bullar lobe is more angular, and the frontomedian lobe is narrower (tr.). The hypostome of scoticus differs from that of grayii in being much narrower (tr.), having a deeper posterior border, and a more incised middle furrow. The pygidium of scoticus is narrower and longer (the axis especially so), the pleural spines are not so pronounced, and the granulation is finer.

Warburg (1925, p.286) considered P.latus (Törnquist, 1884) to be intermediate between P. grayii and P. scoticus. The differences between grayii and scoticus have been outlined above. Although the present author has not seen the type of P.latus the figures and description of Warburg (1925, p.283, pl.7, figs.12-14,16?) are adequate to show that the Girvan form is distinct. The bullar lobe of latus is more pointed anteriorly than posteriorly and the occipital lobe of scoticus is larger and more triangular than that of latus.

2. Platylichas cf. P. scoticus (Reed, 1906)   Pl.20, figs.9a-c.

v.1906 Lichas (Platylichas) grayi, Fletcher, 1850, var. nov. scoticus; Reed, p.100, pl.14, fig.10.

Material, locality and horizon. From Lower Camregan Grits, Locality 19: BM In22734 (Pl.20, figs.9a-c) figured Reed 1906, pl.14, fig.10, cranidium.

Discussion. Only one poorly preserved cranidium of this form is known. It is similar to P. scoticus but the narrowest (tr.) part of the frontomedian lobe is much narrower than that of the older form, and the granulation is more irregular. Because of this morphological difference and the difference in age it is considered advisable to separate this form from the older species until more material is available.

Subfamily CERATARGINAE Tripp, 1957

Genus Hemiarges Gürich, 1901

Type species. Original designation; Lichas wesenbergensis Schmidt 1885, p.44, pl.6, figs.1-4; from Rakvere Limestone (Ordovician), Estonia.

Discussion. For diagnosis and list of other species see Tripp (1958, p.577; in Moore 1959, p.O503).

1. Hemiarges serus (Reed, 1935) Pl.20, figs.7,10-14.

v.1906 Lichas (Corydocephalus) scutalis, Salter 1873; Reed, p.98, pl.14, figs.3,4.

v.1935 Lichas (Platylichas) scutalis Salter var. nov. bella; Reed, p.35, pl.3, fig.9.

v*1935 Lichas (Hemiarges) serus Reed, p.29, pl.3, fig.11.

v.1958 Hemiarges serus (Reed, 1935); Tripp, p.577,579,580, pl.85, figs. 18-20.

Holotype. BM In36953, Pl.20, figs.7a,b, internal mould of cranidium; figured Reed 1935, pl.3, fig.11, refigured Tripp 1958, pl.85, fig.18; from Mulloch Hill Formation, Locality 9.

Material, localities and horizons. From type locality: BM In22728, BM In37072 (Pl.20, figs.10a,b), GSE JS17487, cranidia; BM In36955 (Pl.20, fig.12), figured Reed 1935, pl.3, fig.9 refigured Tripp 1958, pl.85, fig.19, holotype of Lichas (Corydocephalus) scutalis bella Reed 1935, BM In37071, pygidia. From Mulloch Hill Formation, Locality 8: YH R29, YH R118, cranidia. From Mulloch Hill Formation, Locality 6: BM In22722, cranidium; BM In22721, pygidium. From Mulloch Hill Formation, Mulloch Hill (Localities 1-7): YH K3/18 (Pl.20, fig.14), pygidium. From Mulloch Hill Formation, Locality 10: YH G71, pygidium. From Woodland Formation, Locality 18: BM In22791, cranidium; YH WA31, pygidium. From Newlands Formation, Locality 14: BM In43151, In43156, BM It9103, In22718 (Pl.20, fig.11), figured Reed 1906, pl.14, fig.3, HM A3377-84, cranidia; BM It9097, In22724 (Pl.20, figs.13a,b), figured Reed 1906, pl.14, fig.4, refigured Tripp 1958, pl.85, fig.20, HM A10313, A3385, pygidia.

Diagnosis. Cranidium greatly inflated. Frontomedian lobe narrow (tr.) at midlength. Bullar lobe rounded anteriorly, pointed posteriorly, indentated at midlength adjacent to axial furrow, circumscribed. Occipital lobe distinctly delimited posteriorly, indistinctly delimited anteriorly. Anterior border long. Cephalic raised surfaces with irregularly scattered coarse granules. Pygidium small; axis $\frac{1}{2}$ length of pygidium, merging into postaxial ridge which is not delimited from posterior border, 4 to 5 axial rings, all with granules; 3 pairs of pleurae ending in free points. Finely granulated suface with few scattered larger granules.

Dimensions of holotype. Cranidial sagittal length, 3.4mm; width through occipital ring, 2.0mm.

Description. Cranidium approximately 1 1/3 times wider (tr.) than long (sag.), greatly convex longitudinally. Frontomedian lobe greatly convex transversely, $\frac{3}{4}$ length of cranidium, narrowest at about its midlength, expanding greatly anteriorly to 3 times midlength width (tr.), only slight expansion posteriorly. Longitudinal furrow distinct and narrow. Occipital ring with width approximately equal to greatest width of frontomedian lobe; 1/10 cranidial length, decreases laterally to accommodate occipital lobe. Occipital lobe oval in outline, as long as occipital ring, posterior delimiting furrow deeper than anterior furrow. Bullar lobe about 2/3 cranidial length, equal in width to narrowest point (tr.) of frontomedian lobe; oblique, oval in outline, with indentation at midlength adjacent to longitudinal furrow, more rounded anteriorly. Palpebral lobe approximately 1/6 cranidial length, opposite posterior 1/3 of bullar lobe. Axial furrow deep. Anterior border of cranidium broad, as long (sag.) as occipital ring, slightly convex. Posterior border short adaxially, lengthening abaxially; posterior border furrow broad. Fixed cheek convex, bulbous for a part, 1/6 width of cranidium, and $\frac{1}{4}$ cranidial length. Anterior facial suture not clearly defined but appears to run forward exsagittally. Posterior section of facial suture not well defined but probably transverse adjacent to position of palpebral lobe, then turns through 90° and crosses posterior border slightly obliquely. All convex surfaces with irregularly arranged large and small granules, anterior border with only few scattered small granules.

Free cheek approximately 3 times longer (exsag.) than wide, subtriangular in outline, not greatly inflated. Lateral border narrow; lateral border furrow narrow. Posterior border short; posterior border furrow long. Genal angle projected into blunt point. Eye oval in outline, $\frac{1}{2}$ (exsag.) of bullar lobe. Few coarse granules scattered on field of free cheek.

Thorax unknown.

Pygidium 1 1/3 times wider than long. Axis $\frac{1}{2}$ length (sag.) of pygidium and 1/3 width at anterior border, gently convex, tapering slightly posteriorly for first $\frac{1}{2}$ of length, parallel-sided for remaining $\frac{1}{2}$. Axis anterior with distinct first axial ring bounded by broad furrow, second and third axial rings less distinct and bounded by faint furrows; faint fourth furrow indicating presence of fourth and fifth axial rings. Axis ends bluntly. Postaxial ridge tapers rapidly for anterior $\frac{1}{2}$ of its length to $\frac{1}{4}$ its width, then remains parallel-sided uniting with thickened posterior border. First lateral pleura short (exsag.) with raised ridges anteriorly and posteriorly, expanding laterally but narrowing beyond position of fulcrum to pointed free tip, projecting posterolaterally; depressed area in centre of pleura. Second lateral pleura similar to first but longer with a posterior raised ridge only, free tip points posteriorly; depressed area with small ridge for adaxial $\frac{1}{2}$ of pleura width. Third lateral pleura very wide (tr.) incompletely marked off from postaxial ridge posteriorly, free tip projecting posterolaterally; posterior border broad and thickened; depressed area with flattened ridge adjacent to axis anteriorly, expanding posteriorly. Faint raised strip visible in second and third pleura running concentrically parallel to posterior margin in depressed area, reflecting anterior limit of doublure. Second and third axial rings with 2 centrally placed granules, fourth with 2 central granules placed closer together, fifth axial ring with 3 granules, 1 central, posterior extent of axis with 4 granules. All remaining raised surfaces granulated with few coarser granules.

Discussion. This form is assigned to Hemiarges because the occipital lobe is partially fused with 1L, a bullar lobe is present, the pygidium has an axis extending to the posterior border by a narrow postaxial ridge, the posterior bands of the first and second pygidial pleurae are narrower and more swollen than the anterior bands, and the posterior pair of pygidial pleurae are unfurrowed.

H. serus differs from the Wenlock H. scutalis Reed 1901 in the smaller 1L, narrower (tr.) bullar lobe, sculpture with slightly larger but fewer granules, pygidium with axis narrower and tapering more posteriorly with well defined postaxial ridge, inflated pygidial posterior border more distinct, tips of pygidial pleura more pointed, and pygidial sculpture with fine granules and few larger granules

2. Hemiarges rolfei Lamont, 1965 Pl.20, figs.15-18, Pl.21, figs.1-3.

1904 Lichas (Corydocephalus) anglicus (Beyrich), 1846; Reed, p.95.

1961 Hemiarges sp.; Lamont (in Rolfe, p.252) [List].

v*1965 Hemiarges rolfei Lamont, p.33, pl.5, figs.1,1A.

v.1965 Hemiarges sp.; Ibid., p.34.

1965 Hemiarges hughmacdiarmidi Lamont; Ibid., p.34.

1977 Hemiarges rolfei; Clarkson et al., p.121 [List].

Holotype. BU 1896, incomplete internal mould of cranidium with counterpart, figured Lamont 1965, pl.5, figs.1,1A; from the Ree Burn Formation (crenulata Zone), Hagshaw Hills, Scotland.

Material, localities and horizons. From Knockgardner Formation, Locality 24: YH 3K65 (Pl.20, figs.15a,b), YH 3K5 (Pl.21, figs.1a,b), YH 3K2, YH 3K40, 3K34, 3K14, 1K11, 2K5, 2K50, cranidia; YH 3K140 (Pl.20, fig.16), YH 1K27 (Pl.20, fig.18), YH 4K2, hypostomes; GSE M1010[e] (Pl.20, fig.17), YH 3K14 (Pl.21, fig.2), YH 4K19 (Pl.21, fig.3).

Outside the type locality and the Girvan area the species is known from the Wether Law Linn Formation (griestoniensis Zone), North Esk Inlier, Pentland Hills, Scotland.

Diagnosis. Cranidium not greatly convex. Frontomedian lobe parallel-sided for most of length (sag.). Bullar lobe small, rounded anteriorly, pointed posteriorly. 1L long (exsag.), greater in length laterally than bullar lobe. Pygidium with long (sag.) tapering axis. Posterior raised ridges of pygidial pleura and border of pygidium with short pointed spines.

Dimensions of holotype. Cranidial sagittal length, 5.0mm; half cranidial width, 3.0mm.

Description. Cranidium, longitudinal and transverse limits not preserved but would seem to be very slightly wider than long, quite convex longitudinally less so transversely. Frontomedian lobe parallel-sided for most of length expanding anteriorly to 3 times midlength width. Longitudinal furrow deep. Occipital ring slightly longer (sag.) than anterior border, decreasing in length abaxially beyond limits of frontomedian lobe. Occipital lobe not preserved. Occipital furrow narrow, shallower than longitudinal furrow, transverse behind frontomedian lobe. Bullar lobe circumscribed, approximately 1/3 length (exsag.) of cranidium, equal in width (tr.) to narrowest part of frontomedian lobe; kidney shaped in outline, with small indentation at midlength adjacent to longitudinal furrow, rounded anteriorly, pointed posteriorly. Axial furrow deep and wide. 1L delimited from frontomedian lobe by shallow depression, somewhat inflated. Fixed cheek and palpebral lobe not preserved. Anterior border of cranidium long. Anterior section of facial suture not clearly defined but appears to run forwards exsagittally. Posterior section of facial suture not preserved. All convex surfaces with irregular, scattered granules.

Free cheek unknown.

Sagittal and transverse lengths of hypostome unknown. Middle body only very gently convex, $1\frac{1}{2}$ times wider (tr.) than long (sag.) tapering posteriorly to being as long as wide. Middle furrow distinct laterally curving posteriorly and adaxially less distinct and transverse. Macula circular in outline positioned just posterior to middle furrow. Lateral and posterior borders unknown.

Thorax unknown.

Pygidium approximately 1½ times wider (tr.) than long (sag.). Axis tapering gradually posteriorly to ½ axial anterior width (tr.), anteriorly with 5 distinct axial rings with 2 more faintly defined rings behind, terminating bluntly but merging into postaxial ridge. First and second lateral pleurae with raised posterior borders produced into short pointed spines. Faintly raised border produced into short spines. Some symmetrical arrangement of granules on axis but not clearly defined, remainder of pygidium with scattered granules.

Discussion. The parallel-sided frontomedian lobe and long 1L indicate that the Girvan form is identical to H. rolfei from the Hagshaw and Pentland Hills. H. hughmacdiarmidi Lamont (1965, p.34) from the Knockgardner locality appears to be a nomen nudum as no description, type specimen or type locality is given for this species and no prior reference to it has been traced.

The cranidium referred to by Reed (1904, p.95) cannot be traced.

3. Hemiarges hypostome Type A Pl.21, figs.4,7.

Material, localities and horizons. From Mulloch Hill Formation, Locality 9: BM In47720 (Pl.21, fig.7). From Newlands Formation, Locality 14: HM A3386 (Pl.21, fig.4).

Description. Sagittal lengths unknown. Middle body convex 1 1/3 wider than long at maximum width, tapering posteriorly to ½ anterior width. Anterior lobe 2/3 length of middle body. Middle furrow broad, extending to 1/6 width (tr.) of middle body. Anterior margin absent. Lateral border expanding rapidly from opposite widest part of middle body to opposite posterior border furrow. Posterior border unknown. No surface sculpture preserved.

Discussion. See after Hemiarges hypostome Type C.

4. Hemiarges hypostome Type B. Pl.21, figs.5,6.

Material, locality and horizon. From Woodland Formation, Locality 18: YH WC37, YH WA6 (Pl.21, fig.5), YH WAA10 (Pl.21, fig.6).

Description. Similar to Hemiarges hypostome Type A excepting: hypostome 1 1/3 times wider than long; anterior outline of middle body not so strongly curved; middle body 2/3 length (sag.) of whole, not tapering so much posteriorly, and not so inflated; lateral border with anterior transverse edge, no great expansion posteriorly; posterior border ½ length of middle body with angular but shallow indentation of margin; sculpture of middle body pitted and lateral border with striations parallel to lateral edge.

Discussion. See after Hemiarges hypostome Type C.

5. Hemiarges hypostome Type C. Pl.21, fig.8.

Material, locality and horizon. From Mulloch Hill Formation, Locality 5: YH K5/22.

Description. As for Hemiarges hypostome Type B except that: lateral border is narrower (tr.) anteriorly, expanding opposite middle furrow; and posterior border has wide and shallow indentation.

Discussion. The above 3 types of hypostome can be assigned to Hemiarges because of the circumscribed, posteriorly tapering middle body, short middle furrows, and not greatly indented posterior margin. The fragments of dorsal exoskeleton that have been assigned to Hemiarges serus (see above) show no variation to which the 3 hypostomes could be attributed. Consequently, these hypostomes are listed separately.

Family ODONTOPLEURIDAE Burmeister, 1843

Subfamily ODONTOPLEURINAE Burmeister, 1843

Diagnosis. See Whittington (in Moore 1959, p.0504).

Genus Leonaspis Richter & Richter, 1917

Type species. Original designation; Odontopleura leonhardi Barrande 1846, p.58, figured Barrande 1852, pl.37, fig.1; from the Kopanina Formation (Ludlow), Bohemia.

<u>Diagnosis</u>. See Whittington (<u>in</u> Moore 1959, p.O506).

1. <u>Leonaspis</u> cf. <u>L</u>. <u>deflexa</u> (Lake, 1896) Pl.21, figs.9-12.

v.1878 <u>Acidaspis</u> sp.; Nicholson & Etheridge, p.129, fig.7c.

v.1906 <u>Acidaspis</u> <u>deflexa</u>, Lake, 1896; Reed, p.113, pl.15, fig.15.

1925 <u>Acidaspis</u> <u>deflexa</u> LAKE; Warburg, p.235.

<u>Material</u>, <u>localities</u> <u>and</u> <u>horizons</u>. From Mulloch Hill Formation, Locality 9: BM In22831 (Pl.21, figs.10a,b) figured Nicholson & Etheridge 1878, fig.7c, pygidium; BM In22828 (Pl.21, figs.9a,b) figured Reed 1906, pl.15, fig.15, dorsal shield; BM In22829, thorax and pygidium; BM In22830 (Pl.21, figs.11a,b) enrolled specimen. From Mulloch Hill Formation, Locality 8: YH R151, YH R28 (Pl.21, fig.12), pygidia. From Newlands Formation, Locality 14: HM A3288, dorsal shield.

<u>Description</u>. Cephalon, only internal mould known, approximately semicircular in outline widest at posterior border. Frontomedian lobe $\frac{1}{3}$ width (tr.) of cephalon. Only 1L distinguishable, oval in outline, obliquely aligned, anterior limit at about midlength (sag.) of frontomedian lobe. Fixed cheek as a ridge curving forward adaxially dying out before anterolateral limit of frontomedian lobe. Small ridge abaxially concentric to fixed cheek presumably eye ridge. Occipital ring approximately 1/3 width (tr.) of cephalon. Axial furrow indistinguishable. Small oval lobe abaxially adjacent to posterior part of fixed cheek probably represents position of eye. Facial sutures not preserved. Field of free cheek concave. Genal spine broad, expanding posteriorly to opposite seventh thoracic segment and overlapping the first five pleural spines. Row of 11 short, circular in cross-section, spines on doublure of free cheek extending below genal spine.

Thorax of 10 segments. Thoracic axis 1/3 width (tr.) of segment excluding spines. Non-spinose part of pleura straight, transverse and divided into 2 bands of equal length (exsag.). Posterior pleural band higher than anterior band, extending into posteriorly curving spine. Curvature of spines decreases posteriorly with posterior spines being straight and exsagittally directed. Spines 2/3 length of pleura. Doublure restricted to spines.

Pygidium, excluding spines, semicircular in outline, about twice as wide (tr.) as long (sag.). Axis with one distinct ring and terminal piece reaching posterior border. Pleural ridge short, almost confluent with axial ring, curving posteriorly, swollen at base of major spine. Major spine twice length of pygidium. Outside major spine anterior secondary spine ¼ length of major spine. Behind major spine, short spine 2/3 length of major spine. Anterior margin of pygidium straight (tr.) except for anterolateral corner where slightly curved posteriorly. Doublure extends under spines and border.

Discussion. This form is poorly represented with no well preserved cephala available. However, it is possible to assign it to Leonaspis because of the broad based genal spine, the posterior position of the eye and the major pygidial spines with one smaller pair behind. In the latter respect this form resembles L. deflexa (Lake, 1896). The Girvan form differs from L. deflexa in the attitude of the thoracic spines which are less posteriorly directed, in the narrower based genal spine and in the relatively narrower pygidium. Specimen YH R28 (Pl.21, fig.12) from Locality 8, a very elongate pygidium, is considered to be tectonically distorted.

2. Leonaspis aff. L. varbolensis Bruton, 1967 Pl.21, figs.13,16.

1899 Acidaspis Brighti (Murch); Peach & Horne, p.543 [List].

v.1906 Acidaspis coronata, Salter, 1853; Reed, p.113, pl.15, fig.14.

1970 Leonaspis cf. marklini varbolensis Bruton, 1967; Temple, p.69 (pars)

Material, localities and horizons. From Woodland Formation, Locality 18: BM In22825 (Pl.21, figs.13a,b) figured Reed 1906, pl.15, fig.14, SM A35115 (Pl.21, fig.16) pygidia. From Newlands Formation, Locality 14: BM In42705 pygidium.

Description. Pygidium, excluding spines, semi-ellipitical in outline, 3 times wider than long. Axis with 2 rings and terminal piece. First axial ring less than 1/3 width of pygidium across anterior border. Pleural region with raised ridge curving out from adjacent to first axial ring back to base of major spine. Major spine almost exsagittally directed, length unknown. Anterior to major spine, cutlass shaped spine curving backwards to opposite posterior edge of pygidium excluding spines. Behind major spine 2 straight spines, inner fractionally longer and wider. All spines circular in cross-section. Anterior border of pleural area straight, narrower than pleural ridge but as inflated. Indentation laterally, posterior to anterior border and anterior to spines. Posterior border of pygidium strongly raised, swollen at base of spines. Granulation on all spines and in depressions between ridges. Ridges and axis with fainter granulation.

Discussion. The 2 pairs of spines behind the major spines of this pygidium is a feature also seen in L. coronata (Salter, 1853), L. marklini (Angelin, 1854) and L. varbolensis Bruton, 1967. The Girvan form differs from both L. coronata and L. marklini in that both these pygidia have a large granule on the base of each spine. Unfortunately, the pygidium of L. varbolensis is only known as an internal mould but it differs from the Girvan pygidium in that it has straighter anterior spines, no constriction of the lateral border just posterior to the anterior border and the depressed pleural areas are shallower. The similarity of pygidial morphology of marklini, coronata, varbolensis and the Girvan form, and the lack of other fragments of the dorsal shield which could be attributed to the Girvan pygidium has caused the author to refer the latter to varbolensis because of the similarity of age (lowermost Llandovery).(marklini and coronata are Wenlock - Ludlow forms). Temple (1971, p.69) considered pygidium BM In22825 (Pl.21, figs.13a, b) from Locality 18 to be conspecific with his Leonaspis cf. marklini varbolensis Bruton 1967, from Meifod. The Meifod pygidium is poorly preserved, is distorted, and hence it is difficult to compare with any other form. The Meifod form is described as possessing small granules in the depressed pleural areas and having no large granule at the base of the spines. Until better material is available from Meifod and Girvan it is unwise to regard the forms as conspecific.

3. Leonaspis sp. indet. A. Pl.22, fig.1

Material, locality and horizon. From Woodland Formation, Locality 18: BM In22819 incomplete cranidium.

Description. Cranidium twice as wide as long. Frontomedian lobe considerably swollen expanding anteriorly, tapering to blunt point posteriorly, anterior margin rounded, sloping steeply down to anterior border furrow. Occipital ring with small occipital lobe and median granule; occipital furrow distinct. 1L oval in outline, long axis almost exsagittal and about ½ length (sag.) of frontomedian lobe. 2L small, circular in outline. Longitudinal furrow shallow and broad between 2L and frontomedian lobe, deep and narrow opposite anterior ½ of 1L, widening rapidly and shallowing posteriorly. 1S very deep, curved and extending to axial furrow. 2S deep only slightly curved, running steeply down and forward abaxially. Axial furrow distinct. Palpebral lobe opposite posterior ½ of 1L adjacent to posterior border furrow. Eye ridge narrow curving anteriorly, dying out at frontomedian lobe. Anterior section of facial suture defined by sutural ridge diverging from eye ridge opposite 1S, running straight anteriorly, curving slightly adaxially across anterior border. Posterior section of facial suture indistinct except where cuts posterior border. Anterior border straight, anterolateral corner flat. Anterior border furrow very deep and slit-like adjacent to eye ridge. Posterior margin straight and border convex, Frontomedian lobe, 1L, 2L, triangle of fixed cheek and occipital ring coarsely granulated. Furrows, anterior border and eye ridge very finely granulated.

Discussion. See after Leonaspis sp. indet. E.

4. Leonaspis sp. indet. B. Pl.21, figs.15,17,18.

Material, localities and horizons. From Mulloch Hill Formation, Locality 6: HM A3291 (Pl.21, fig.18). From Mulloch Hill Formation, Locality 8: YH R19 (Pl.21, fig.17). From Woodland Formation, Locality 18: BM In22821 (Pl.21, fig.15). All cranidia.

Description. Cranidium very similar to Leonaspis sp. indet. A except that it has a much longer (sag.) occipital ring and a narrower longitudinal furrow. The frontomedian lobe is not so greatly inflated, has a transverse posterior margin, is parallel-sided anteriorly except for slight indentation opposite 2L, and decreases in width from ⅓ length of 1L to posterior limit.

Discussion. See after *Leonaspis* sp. indet. E.

5. *Leonaspis* sp. indet. C. Pl.22, fig.2.

Material, locality and horizon. From Newlands Formation, Locality 14: YH NW118 cranidium.

Description. Immature cranidium with parallel-sided frontomedian lobe. 1L oval in outline; 2L smaller. Occipital ring as wide as frontomedian lobe with median, large granule and 2 either side, with bases of pair of occipital spines. Frontomedian lobe with large granules vaguely arranged in rows. 1L with pair of large granules, 2L with 1 granule.

Discussion. See after *Leonaspis* sp. indet. E.

6. *Leonaspis* sp.indet. D. Pl.21, fig.14.

Material, locality and horizon. From Mulloch Hill Formation, Locality 8: SM A34857 free cheek.

Description. Cheek border wide and flattened. Genal spine short, swollen at base, directed outwards and backwards, curved slightly at distal end. Cheek border with at least 8 short, peg-like spines. Field of free cheek concave but sloping up to eye lobe. Genal spine sparsely granulated. Rest of surface sculpture indistinct.

Discussion. See after *Leonaspis* sp. indet. E.

7. *Leonaspis* sp. indet. E. Pl.21, fig.19.

Material, locality and horizon. From Woodland Formation, Locality 18: BM In22827 thoracic segment.

Description. Thoracic axial ring 4 times wider (tr.) than long (sag.) and 1/3 width (tr.) of non-spinose part of pleura. Articulating half ring as long (sag.) as axis (sag.). Axis granulated; articulating half ring lightly granulated; articulating furrow without sculpture. Non-spinose part of pleura with long (exsag.) convex principal ridge, ½ length of pleura; convex anterior pleural band and posterior pleural band; pleura swollen at fulcrum. Principal ridge and posterior band extended into straight, obliquely posteriorly directed pleural spine. Spine about twice length of non-spinose part of pleura. Pleura without sculpture.

Discussion. There are 2 types of holaspid Leonaspis cranidia from the Rhuddanian and Idwian of Girvan. One form with a pointed posterior margin to the frontomedian lobe (type A), and the other with a straight posterior margin (type B). These cannot be assigned to either of the early Llandovery species described above (L. cf. L. deflexa and L. aff. L. varbolensis) as no well preserved, complete specimens of the latter forms have yet been found to indicate which cranidium is attributable to which pygidium. Three almost complete specimens with a deflexa-like pygidium are known but in each case the cephalic region is very poorly preserved. The holotypes of L. varbolensis and L. deflexa both have straight or nearly straight posterior margins to the frontomedian lobe. Temple (1971, p.69) referred BM In22819 and BM In22821 (described above as Leonaspis sp. indet. A and B respectively) to his L. cf. marklini varbolensis Bruton, 1967. Unfortunately, Temple's figured cranidium (pl.19, fig.17) from Meifod is very small and hence difficult to compare closely with other forms.

Cranidium type A differs from L. marklini, L. varbolensis, L. deflexa and the material referred to L. cf. marklini varbolensis by Temple in having a finer granulation, a pointed posterior edge to the frontomedian lobe, a wide and less sinuous longitudinal furrow, and a frontomedian lobe which does not expand laterally infront of 2L. Type A differs from all other Leonaspis species in the pointed posterior margin of the frontomedian lobe. Cranidium type B is similar to the 4 taxa mentioned above in having a transverse posterior margin of the frontomedian lobe but differs from L. varbolensis in being less coarsely granulated, the frontomedian lobe not as inflated anteriorly, and the occipital furrow longer (sag.). It differs from L. deflexa chiefly in that the latter has a parallel-sided frontomedian lobe and a short occipital furrow. The Meifod form referred by Temple to L. cf. marklini varbolensis has a shorter (sag.) occipital furrow, a narrower posterior to the frontomedian lobe and is coarsely granulate. Cranidium type B differs from L. marklini in being more finely granulated.

8. Leonaspis acarescola sp. nov. Pl.22, figs.3-5.

Name. Greek 'acares', meaning short and 'skolos', meaning thorn; pertaining to the shape of the genal spine.

v.1879 Acidaspis sp. ind.; Nicholson & Etheridge, p.206, pl.14, fig.14.

1899 Acidaspis sp.; Peach & Horne, p.538 [List].

1906 Acidaspis coronata, Salter, 1853; Reed, p.113

Holotype. GSE 5776, Pl.22, figs.4,5, external mould of almost complete dorsal shield with hypostome; figured Nicholson & Etheridge 1879, pl.14, fig.14; from Wood Burn Formation, Locality 21 (Bargany Pond Burn).

Paratype. Very poorly preserved, almost complete, internal mould of dorsal shield on same slab as type specimen, Pl.22, fig.3.

Diagnosis. A Leonaspis with regular arrangement of large granules on frontomedian lobe. Longitudinal furrow deep and sinuous. Genal spine short. Lateral border spines of free cheek and pygidial spines very short. 2 pairs of spines behind major pygidial spines, 1 pair anterior.

Dimensions of holotype. Sagittal length of dorsal shield, 10.0mm; width across posterior border of cephalon, 7.0mm; sagittal length of cephalon, 3.5mm.

Description. Cranidium twice as wide (tr.) across posterior border as long (sag.). Frontomedian lobe gently convex, but highest part of cranidium; anterior margin rounded, sloping very steeply down to anterior border furrow; posterior margin more transverse. Longitudinal furrow sinuous, curving adaxially opposite 1L and 2L, shallowest at these points, more strongly curved opposite 1L and remains at most adaxial limit posteriorly. Occipital ring twice as wide (tr.) as long (sag.), with occipital lobe as very small lateral swelling and with median granule. Occipital furrow long (sag.) and shallow. 1L $\frac{1}{4}$ cranidial length, suboval in outline, anterior limit pointed, long axis lying at slight angle to median line. 2L same as 1L but smaller. 1S straight, shallow laterally, deepening adaxially just reaching axial furrow. 2S deep and very short. Axial furrow wide and shallow, deepest opposite 2S. Palpebral lobe opposite posterior $\frac{1}{2}$ of 1L. Field of fixed cheek sickle-shaped in outline, dying out opposite 2S. Eye ridge narrow curving anteriorly, dying out at anterior limit of frontomedian lobe. Anterior section of facial suture diverges from eye ridge opposite 1S, runs straight to opposite 2L then cuts anterior border at an angle. Posterior section of facial suture runs transversely for most of length before cutting obliquely across posterior border. Anterior border straight. Anterior border furrow very deep laterally shallowing to $\frac{1}{2}$ that depth infront of frontomedian lobe. Posterior margin straight. Posterior border convex expanding laterally. All surfaces, including furrows, very faintly granulated; raised surfaces with occassional larger granules, frontomedian lobe with symmetrical arrangement of granules (see Pl.22, fig.4). Free cheek twice as wide (tr.) as long (exsag.). Lateral border 1/5 width of cheek with unknown number of very short spines. Posterior border wider than lateral border. Genal angle greatly swollen and produced into short, thorn-like spine. Lateral and posterior border furrows wide, shallow posterolaterally, deepening anteriorly. Field of free cheek sloping from furrow upwards to base of eye lobe. Eye not preserved. All surfaces very finely granulated, a few larger granules on genal spine especially on the swollen base.

Rostral plate unknown.

Hypostome, only known as internal mould, 1 1/3 times wider (tr.) than long (sag.), anterior margin straight with short distally directed wings. Posterior margin slightly curved with short stump posteriorly directed at midpoint; posterior border slightly concave, approximately 1/5 length (sag.) of hypostome. Posterolateral margin rounded. Lateral margin straight with posterior wing positioned at midlength of hypostome. Middle body gently convex, highest point just posterior to midlength. Border furrow narrow anteriorly widening posteriorly. No surface sculpture on internal mould.

Thorax 1 3/5 wider (tr.) than long (sag.) with 10 segments. Axis ¼ width (tr.) of thoracic segment. Articulating half ring not known. Pleura transverse with narrow anterior and posterior flanges. First 2 segments without pleural spines. Principal pleural ridge slightly swollen at fulcrum and produced into short pointed spine. All raised surfaces finely granulated. Anterior pleural flange with 1 row of closely spaced very small granules.

Pygidium twice as wide (tr.) as long (sag.), excluding spines, with straight anterior margin. Axis only very slightly raised with 2 rings, triangular terminal piece flattened and indistinct. Remainder of pygidial surface flattened with only very small triangular depressions of pleural areas visible. Single anterior secondary spine outside major spine. Between major spines four shorter spines. All spines short and wide terminating in blunted tips. All surfaces very finely granulated.

Discussion. This form differs from all other known species of *Leonaspis* in its relative lack of strong sculpture, effacement of pygidial features, and relative shortness of all the spines. The narrowness of the posterior part of the frontomedian lobe also occurs in *L. marklini* (Angelin, 1854) and *L. varbolensis* Bruton, 1967 but the Girvan form differs from these chiefly in sculpture (they are much more heavily granulated), longer (sag.) occipital ring, and frontomedian lobe almost touching the anterior margin of the anterior border.

9. *Leonaspis* cf. *L. angelini* (Prantl & Přibyl, 1949) Pl.22, figs.6,7.

Material, locality and horizon. From Wood Burn Formation, Locality 21: GSM YFF9394 (Pl.22, fig.6), thorax and pygidium; YH B13 (Pl.22, fig.7), pygidium.

Description. Cephalic region unknown. Thorax 1¼ times longer (sag.)

than wide (tr.), excluding spines, tapering rapidly posteriorly, with ?10 segments. Axis 1/3 thoracic width anteriorly, narrowing posteriorly. Pleura transverse proximally with anterior and posterior flanges of unknown length. Principal pleural ridge slightly swollen at fulcrum then produced into very long, backwardly directed slender spine; anterior spines equal in length to thorax, posteriorly decreasing in length slightly. Axis with 2 large granules symmetrically placed eitherside of median line. Pleura with large granule midway between fulcrum and axial furrow.

Pygidium twice as long, excluding spines, with straight anterior margin. First axial ring 1/5 pygidial length (sag.), 3/8 width (tr.), shorter (sag.) medially, inflated posteriorly distally, connected by short pleural ridge into backwardly directed major spine of unknown length. Articulating half ring ¼ width of pygidium. Second axial ring ¼ width (tr.) of pygidium and 1/6 length (sag.), joined by axial terminal piece to posterior border. Posterior border convex, 1/6 length (sag.) of pygidium merging into narrower anterior border. Behind major spine a short stout spine approximately 1/3 length (sag.) of pygidium. Outside major spine short anterior secondary border spine. Outer pleural area deeply impressed just anterior to pleural ridge shallowing anteriorly. Inner pleural area very deeply impressed. Axial rings each with pair of large granules, all other surfaces very finely granulated.

Discussion. The pygidium YH B13 has been associated with the thorax GSM YFF9394 because of the similarity with *L. angelini* (see Bruton 1967, pl.34, fig.4). *L. angelini* has a rapidly tapering thorax with very long pleural spines and a pygidium comparable with YH B13. The thorax of the Girvan form and *angelini* are very similar, the former having longer pleural spines. The pygidia differ however in the more distinct second axial ring, shorter inner pair of spines and lack of granules on the pleural ridge of the Girvan form.

Genus *Anacaenaspis* Bruton, 1967

Type species. Original designation; Anacaenaspis gotlandensis Bruton 1967, p.236, pl.35, fig.10, pl.36, figs.2-5; from the Hemse Beds (Middle Ludlow), Petesvik in Hablingbo, Gotland.

Diagnosis. See Bruton (1967, p.235).

Other species. A. emarginata (Schmidt, 1885); A. kruegeri (Schrank, 1969); A? longispinus (Maksimova, 1968); Odontopleurinae indet. Temple, 1975.

Discussion. The differences of Anacaenaspis and Primaspis Richter & Richter, 1917 have been discussed by several authors. Schrank (1969, p.723) considered Anacaenaspis a subjective junior synonym of Primaspis because when first diagnosed Anacaenaspis was compared only with Acidaspis. Schrank regarded that this latter genus differed in the same characters from Primaspis and he considered that anterior auxiliary thoracic spines were characteristically typical of Primaspis. Přibyl & Vaněk (1973, p.303) regarded it as a junior synonym of Primaspis (Meadowtownella) Přibyl & Vaněk, 1965, because they considered that Anacaenaspis had been established on features which were not recognised by Bruton (1968, p.10) as being valid for their P. (Meadowtownella). Perry & Chatterton (1977, p.312) agreed with Přibyl & Vaněk. The present author disagrees with the above authors and considers Anacaenaspis to possess characters which set it aside from all other Odontopleurinae genera. The distinguishing features of Anacaenaspis are a very long (sag.) occipital ring (about ½ length of frontomedian lobe) which is convex and at same height as frontomedian lobe, a short (sag.) occipital furrow, 1L long (often over ½ length of frontomedian lobe), ellipitical in outline (as opposed to oval in Primaspis), very long genal spines equalling full length of thorax and pygidium, with a very broad base, tips of long lateral border spines of free cheek pointing posteriorly, field of fixed cheek narrow (tr,) especially posteriorly, anterior pleural spines well developed and long, and strong anterior border to the pygidium.

Primaspis (Meadowtownella) (type species P. whitei Whittard 1961, p.199, pl.27, figs.1-7), can be distinguished from Anacaenaspis by its short occipital ring, well defined occipital lobes and very wide (tr.) field of fixed cheek especially posteriorly.

Anacaenaspis callipareos (Thomson, 1857) Pl.22, figs.8-12, Pl.23, fig.1; Text-figs.38,39.

1857 Acidaspis callipareos Thomson, p.208, pl.6, figs.11,12.

1867 Acidaspis callipareos Wyv. Thom; Bigsby, p.33.

1876 Acidaspis callipareos Wyv. Thoms.; Armstrong et al., p.15.

1877 Acidaspis callipareos Thomson, 1857; Woodward, p.18.

1878 Acidaspis callipareos, Wyv. Thomson; Nicholson & Etheridge, p.125.

1896 Acidaspis callipareos Wyv. Thomson; Lake, p.243.

v.1906 Acidaspis callipareos, Wyville Thomson, 1857; Reed, p.112, pl.15, figs.12,13.

1925 A. callipareos Wyv. Thoms.; Reed, p.71.

1925a Leonaspis callipareos Wyv. Thoms.; Reed, p.428.

v.1935 Acidaspis (Acidaspis) commoda Reed, p.40, pl.3, fig.22.

1949 Acanthaloma (?Kettneraspis) callipareos (WYV. THOMSON, 1857); Prantl & Přibyl, p.166.

Type data. The syntypes of this species (figured Thomson 1857, pl. 6, figs.11,12) have not been traced in any of the major palaeontological collections in Britain. A neotype is not selected here as the type specimens may yet be found, (see Appendix III, Page 209).

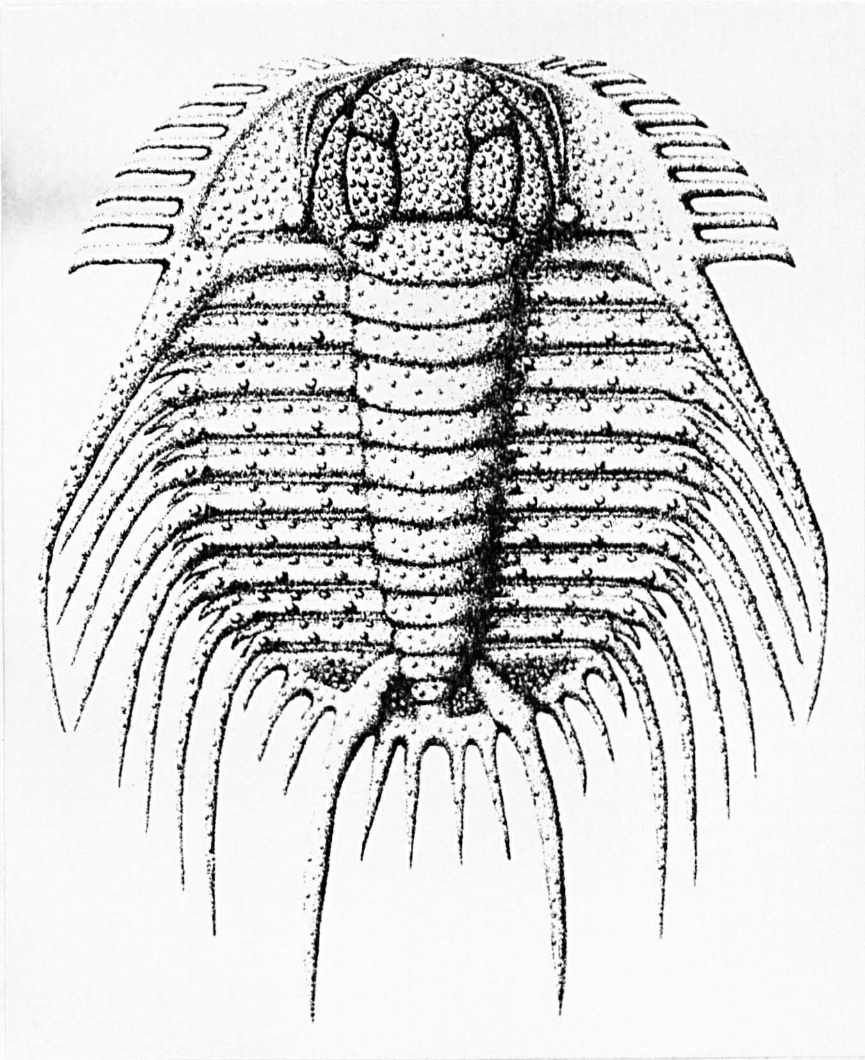
Type locality. "Mulloch Hill sandstone, Girvan" (see Thomson 1857, p.208).

Material, localities and horizons. From Mulloch Hill Formation, Locality 9: BM In36956 (Pl.22, fig.12), figured Reed 1935, pl.3, fig.22 as holotype of Acidaspis (Acidaspis) commoda, BM In37029 (Pl.22, fig.8), BM In 47725, cranidia; BM In47742 (Pl.22, fig.13), BM In42680, cephala. From Mulloch Hill Formation, Locality 8: YH R62, cranidium. From Woodland Formation, Locality 18: BM In37030 (Pl.22, figs.10a-c), dorsal shield with hypostome; YH WC36, BM In22817 (Pl.22, fig.9) figured Reed 1906, pl.15, fig.12, cephala.

From Newlands Formation, Locality 14: HM A3289 (Pl.22, fig.11), HM A2964, cephala; HM A3295 cranidium; HM A3290 (Pl.23, fig.1), free cheek; HM A3296, pygidium.

Diagnosis. 1L and occipital ring long. Eye lobe far back almost on posterior border but raised above most of cephalon. Long fringing cephalic border spines. Very long genal spine. Cephalon coarsely granulate. Pleura with anterior band with row of granules and produced into long spine, posterior band non-granulate. Principal pleural ridge with 3 large granules, produced with posterior band into long spine. Pygidium 4 times wider (tr.) than long (sag.), with strongly raised anterior and posterior borders. 3 spines anterior to major spine, 2 behind. Pleural field granulated.

Description. Cephalon 2 2/3 wider (tr.) than long (sag.). Cranidium 1 2/3 wider (tr.) than long (sag.), width taken across posterior border. Frontomedian lobe constricted at 1L and 2L but sloping steeply down to anterior border furrow. Occipital ring 1/3 length (sag.) of cranidium, posterior margin semicircular in outline. Occipital lobes small and ill-defined. Occipital furrow very narrow (sag.). 1L oval in outline with long axis slightly oblique to sagittal line, 2/5 cranidial length and short axis $\frac{1}{8}$ width (tr.) of cranidium. 2L similar to, but smaller than, 1L with long axis equal in length to short axis of 1L, and more obliquely aligned. 3L small, transverse swelling on side of frontomedian lobe. Longitudinal furrow narrow, distinct, deep and curving adaxially opposite lateral glabellar lobes. 1S straight, obliquely aligned at 30° to sagittal line, reaching axial furrow, shallower than longitudinal furrow. 2S as 1S. Axial furrow curving, distinct. Fixed cheek ridge-like, wider (tr.) posteriorly than anteriorly, terminating at 2S. Eye ridge parallel to fixed cheek, narrow, dying out at frontomedian lobe. Anterior section of facial suture defined by sutural ridge, parallel with eye ridge to opposite 1S then diverges, most anterior limit not preserved on specimens. Posterior section of facial suture oblique from eye to just adaxial of genal spine where crosses posterior border. Anterior border straight; posterior border straight widening laterally. Antennula notch just behind



TEXT-FIG.38. Anacaenaspis callipareos (Thomson, 1857). Reconstruction of dorsal shield based on specimen BM In37030. Approximately x2.5.

anterior border. All raised areas of cranidium coarsely granulated, posterior border very slightly granulated. Free cheek triangular in outline. Eye small, rounded and raised, approximately level with occipital furrow. Lateral border of free cheek convex, wide (tr.) with 10 narrow border spines decreasing in length anteriorly, longest being equal in length to width of glabella, distal ends of border spines slightly clubbed and pointed posteriorly. Genal angle produced into spine at least twice length (sag.) of cranidium. All surfaces with granules of various sizes, spines only slightly granulated.

Hypostome subquadrate in outline, approximately $\frac{1}{2}$ length (sag.) of glabella and occipital ring, as wide (tr.) as long (tr.). Middle body gently

TEXT-FIG.39. Anacaenaspis callipareos (Thomson, 1857).
Reconstruction of hypostome based on specimen BM In37030.
Approximately x3.

convex with curved posterior margin. Middle furrow short, oblique, antero-lateral extent unknown but dying out below level of posterior wing, deepest opposite posterior wing. Anterior border not preserved. Lateral border narrow with small posterior wings at ½ length (sag.) of hypostome. Posterior border broader than lateral border, with median notch. Raised surfaces lightly granulated, furrows without sculpture.

Thorax of 10 segments. Width (tr.) of axis at least equal to that of non-spinose part of pleura. Axis lightly granulated. Non-spinose part of pleura 3 times as wide (tr.) as long (exsag.), with broad (exsag.) convex principal ridge 1/3 length (exsag.) of pleura; convex anterior pleural band with 1 row of granules and smooth posterior band. Principal pleural ridge with one granule, ½ width (tr.) of non-spinose part of pleura, 1 granule adjacent to axis, and 1 granule on swollen fulcrum. Principal ridge and posterior band extended into pleural spine less than twice length of non-spinose part of pleura. Spine lightly granulated. Anterior band extends into spine of length greater than length (exsag.) of pleura.

Pygidium 4 times as wide (tr.) as long (sag.) excluding spines. Axis not well preserved but probably with 1 axial ring and terminal piece. Pleural region with raised ridge running directly back from adjacent to first axial ring to major spine. 3 posteriorly curved spines outside major spine, 2 spines inside. All spines of unknown length. Anterior margin straight. Posterior border strongly raised, swollen at base of spines. Granulation in depression between ridges. Ridges and spines only lightly granulated.

Discussion. The antennular notch, the long fringing spines of the free cheek, the long (sag.) occipital ring, the non-development of the posterior sutural ridge, the principal pleural ridge of pleura swollen at fulcrum and the pygidium with 4 spines between the major spines indicate that this species should be referred to *Anacaenaspis*.

Thomson (1857, p.208, pl.6, figs.11,12) did not give a full description of his new species and as the types have not been traced comparisons have been made with his published figures. Thomson states that his specimens are from the "Mulloch Hill sandstone"; hence they may be from Localities 8 or 9 or from from one of the localites along the Mulloch Hill High Road (Localities 1-7). Although no specimen determined here as *A. callipareos* has 1L as long as those shown by Thomson's figure they are similar in all other respects and are referred to Thomson's species.

Acidaspis commoda Reed, 1935 cannot be separated from *A. callipareos* because of its long 1L lobe and occipital ring and hence is considered a junior subjective synonym of *A. callipareos*.

Genus *Globulaspis* Reed, 1931a

Type species. Original designation; *Acidaspis* (*Globulaspis*) *prominens* Reed 1931a, p.100, pl.5, figs.5,5a,b; from Newlands Formation, Locality 14 (Newlands Farm), Girvan, Strathclyde Region, Scotland.

Diagnosis. Genus only known from cranidium. Frontomedian lobe greatly inflated, virtually parallel-sided, anteriorly bluntly terminated, posteriorly tapering to point. Occipital furrow and ring long (sag.). 1L greatly inflated, with steep sides, long (exsag.) and narrow (tr.) completely isolate from frontomedian lobe because of very deep 1S. 2S very shallow. 2L as small swelling on side of frontomedian lobe delimited adaxially by very shallow longitudinal furrow. Axial furrow deep and wide posteriorly, shallowing anteriorly. Fixed cheek and eye ridge inflated.

Discussion. Previously this genus was only known from one cranidium (Reed 1931a, pl.5, figs.5,5a,b) and its affinities have been in doubt (Prantl & Přibyl 1949, p.133). Whittington (1956a, p.283) queried that the form was even an odontopleurid. However, with the discovery of more specimens, albeit only cranidia, it can now with certainty be assigned to the Odontopleuridae, because the maximum width of the glabella is at the occipital ring, there are two lateral glabellar lobes, an eye ridge curves forwards dying out just before the frontomedian lobe, the anterior section of the facial suture runs forwards and inwards, the posterior section runs backwards and outwards, and the presence of a sutural ridge. Globulaspis is here placed in the Odontopleurinae because of the glabella which tapers forwards, the absence of a third glabellar lobe, the posteriorly positioned eye lobe, and the anterior and posterior sections of the facial suture subtending an angle of over 90° at the eye lobe. Globulaspis can be compared with Whittingtonia Prantl & Přibyl, 1949 because of the strikingly convex, suboval frontomedian lobe. However, Whittingtonia differs significantly from Globulaspis in not having a long preglabellar field, possessing 3L lobes, having a posterior band on the frontomedian lobe, poorly developed 1L lobes and occipital spines.

Globulaspis prominens Reed, 1931a Pl.23, figs.3,4,6.

v*1931a Acidaspis (Globulaspis) prominens Reed, p.100, pl.5, figs.5,5a,b.

1949 Globulaspis prominens Reed, 1931; Prantl & Přibyl, p.124,133,206, 212.

1956a Globulaspis prominens Reed, 1931; Whittington, p.283.

Holotype. HM A1066, Pl.23, fig.4, internal mould of cranidium; figured Reed 1931a, pl.5, figs.5,5a,b; from Newlands Formation, Locality 14.

Material, locality and horizon. From type locality: SM A74590 (Pl.23, fig.6), BM In22824, HM A10675, YH NW39, YH NW41, YH NW40, YH NW42 (Pl.23, figs.3a-c), cranidia.

Diagnosis. As for genus.

Dimensions of holotype. Sagittal length of cranidium, 7.0mm; width across posterior border, 13.0mm.

Description. Cranidium a little more than twice as wide across posterior border as long. Frontomedian lobe greatly inflated, twice as long (sag.) as wide (tr.), parallel-sided for anterior ⅓ of length but tapering posteriorly, anterior margin blunt sloping steeply down to preglabellar field. Preglabellar field 1/10 length (sag.) of frontomedian lobe. Longitudinal furrow only visible as shallow, broad area between 2L and frontomedian lobe. Occipital ring long (sag.) with no evidence of occipital lobe; occipital furrow long (sag.). 1L large, oval in outline its long axis exsagittally aligned and 1/3 length (exsag.) of frontomedian lobe. 2L circular, very much reduced, 1/5 length (exsag.) of 1L. 1S very deep, steep-sided, straight, lying 30° from sagittal line widening at axial furrow. 2S very shallow depression just visible on side of frontomedian lobe, running steeply down to axial furrow parallel with 1S. Axial furrow wide and deep posteriorly, shallowing anteriorly. Fixed cheek ridge-like, wide (tr.) posteriorly terminating just anterior to 2L. Wide furrow between fixed cheek and eye ridge. Eye ridge dying out just before frontomedian lobe. Palpebral lobe not preserved on any specimen, but probably positioned opposite 1L. Anterior section of facial suture with sutural ridge parallel to eye ridge but diverges opposite 2L, cutting anterior border level with abaxial edge of 1L. Posterior section of facial suture running slightly posteriorly before cutting posterior border at very low angle. Anterior border straight, rolled, 2/5 width of cranidium. Anterior border furrow narrow but wider between eye ridge and anterolateral corner. Posterior margin straight; border convex, lengthening (exsag.) abaxially. Frontomedian lobe, 1L, occipital ring and triangle of fixed cheek with few coarse granules; 2L with one large granule; anterior border finely granulated; eye ridge, furrows and sides of frontomedian lobe without sculpture. Sculpture of posterior border unknown as only internal moulds available.

Discussion. This species appears to be restricted to the Newlands Formation of the Girvan area.

Odontopleurinae gen. indet. Pl.23, fig.2.

Material, locality and horizon. From Newlands Formation, Locality 14: HM A3296 pygidium.

Description. Pygidium, internal mould, 3 times wider (tr.) than long (sag.), excluding spines. Axial region not preserved. Pleural ridge running directly back from position of first axial ring to swollen base of major spine. Infront of major spine 4 posteriorly curved spines; behind spine 2 minor spines. All spines of unknown length. Anterior margin straight. Faintly delimited posterior border. Pleural areas with raised, large granules showing some indication of radial alignment. Pleural ridge, spines and posterior border sparsely granulated. All granules narrower in diameter at their base.

Discussion. It is impossible to assign this specimen to a genus because of its poor preservation.

Subfamily MIRASPIDINAE Richter & Richter, 1917

Genus Miraspis Richter & Richter, 1917

Type species. Original designation; Odontopleura mira Barrande 1846, p.57; from the Motôl Beds (Upper Wenlock) of Bohemia.

Diagnosis. See Whittington (in Moore 1959, p.O506).

Miraspis ultima Reed, 1931 Pl.23, figs.7,9,10.

v*1931 Acidaspis (Miraspis) ultima Reed, p.99, pl.5, figs.6,6a.

1931a Acidaspis (Miraspis) ultima Reed; Reed, p.25.

Holotype. HM A1065, Pl.23, figs.9a,b, internal mould of cranidium; figured Reed 1931, pl.5, figs.6,6a; from Newlands Formation, Locality 14.

Material, locality and horizon. From type locality: BM In22822 (Pl.23, figs.7a-c), cranidium; BM In42696, cranidium and 7 segments; SM A74679 (Pl.23, fig.10), BM In22823, thoracic segments.

Diagnosis. Frontomedian lobe parallel-sided. 3 perhaps 4 lateral glabellar lobes. Occipital ring with spines 4 times longer than cranidium. Palpebral lobe pedunculate. Principal pleural ridge of thoracic segment produced into long spine.

Dimensions of holotype. Sagittal length of cranidium, 5.0mm; width across 1L lobes, 5.0mm.

Description. Cranidium as wide (tr.) as long (sag.), widest at base of pedunculate palpebral lobe. Frontomedian lobe parallel-sided, approximately 1/5 width (tr.) of cranidium. Occipital ring wider (tr.) than long, with large median granule at base of paired occipital spines which are at least 4 times longer (sag.) than cranidium. Occipital furrow broad. 1L circular in outline. 2L smaller and almost square in outline. 3L smaller again but same shape as 2L. ?4L very small and ridge-like narrowing abaxially. Longitudinal furrow distinct, shallower opposite lateral glabellar lobes, dying out at anterior extent of frontomedian lobe. Axial furrow only present adjacent to 1L. 1S distinct, transverse adaxially, curving posteriorly abaxially. 2S parallel to 1S but shorter. 3S almost transverse. 4S parallel to 3S. Eye ridge narrow and slightly curved. Palpebral lobe pedunculate, total length unknown but known length equal to width (tr.) of glabella across 1L lobes. Anterior section of facial suture from base of pedunculate palpebral lobe curving gently forwards to anterior margin. Posterior section of facial suture runs straight back from palpebral lobe as far as posterior border; posterior width of cranidium unknown. Posterior of cranidium (internal mould) straight with rolled border; border furrow shallow. Frontomedian and lateral glabellar lobes, and fixed cheeks coarsely granulated with occasional larger granules. Occipital ring with few scattered granules. Occipital spines and posterior border of cranidium without sculpture. Large granule on posterior border opposite base of pedunculate palpebral lobe.

No free cheek, hypostome, or rostral plate known.

Thorax, only parts of 7 segments known. Axis less than ½ width (tr.) of non-spinose part of pleura, strongly convex. Axis with few scattered granules but articulating furrow and half ring without sculpture. Principal pleural ridge 1/3 length (exsag.) of pleura, weakly convex. At fulcrum ridge slightly swollen but tapers outwards into long posterior pleural spine. Latter slender, 1 1/3 width of non-spinose part of pleura in length, curving posteriorly. Anterior convex band of pleura with coarse row of granules on posterior margin; band extends into short anterior spine. Posterior band concave, just under 1/3 length (exsag.) of non-spinose part of pleura. Anterior flank of pleural ridge lightly granulated, pleural ridge bare except for one large granule positioned ¾ width (tr.) from axis; posterior flank also lightly granulated, and posterior band without sculpture.

Discussion. This species is restricted to the Newlands Formation. It has been assigned to *Miraspis* because of the pedunculate eye positioned opposite 1L, presence of 3L, and paired occipital spines. The non-inflated glabella, the well developed 3L and the very long occipital spines separates *M. ultima* from other known species of *Miraspis*.

Genus *Ceratocephala* Warder, 1838

Type species. By monotypy; *Ceratocephala goniata* Warder 1838, p.377; from the Niagaran (Silurian), Ohio, U.S.A.

Diagnosis See Whittington (*in* Moore 1959, p.O507).

Ceratocephala sp. Pl.23, fig.11.

1899 *Acidaspis bispinosus* (M'Coy); Peach & Horne, p.536 [List].

v.1906 *Acidaspis barrandei* Fletcher & Salter, 1853; Reed, p.112, pl.15, fig.11.

Material, locality and horizon. From Wood Burn Formation, Locality 22; BM In22816, figured Reed 1906, pl.15, fig.11, cephalon.

Description. Cephalon, almost complete but much damaged and exfoliated in parts; approximately twice as wide (tr.) at posterior border as long (sag.) excluding spines. Frontomedian lobe approximately twice as long (sag.) as wide (tr.), parallel-sided opposite 1L, expanding anteriorly, greatly convex. Longitudinal furrow shallow opposite 2L and anterior to that but deeper posteriorly. Occipital ring equal in width (tr.) to frontomedian lobe, 4 times wider (tr.) than long (sag.) with incomplete pair of long curved spines, at least 1¼ times longer than cephalon, possibly with median granule. Occipital lobes not preserved. Occipital furrow shallow and long (sag.). Axial furrow very weakly defined. 1L oval in outline, 1¼ times longer (exsag.) than wide (tr.), ⅓ length (exsag.) of frontomedian lobe, only slightly inflated. 2L smaller than 1L, 1/3 length (exsag.) of frontomedian lobe, almost confluent with fixed cheek. 1S deep proximally, shallowing rapidly to axial furrow, straight, aligned at 45° to exsagittal line. 2S similar to 1S. Fixed cheek ill-preserved. Eye ridge just discernable running backwards and outwards from anterolateral corner of frontomedian lobe to position opposite base of 2L. Facial sutures not preserved. Free cheek adaxial limits undefined but convex lateral and anterior borders. Genal spine slightly swollen at base, incomplete but at least 1 1/3 times longer (sag.) than cephalon. Posterior border of cephalon not preserved. Frontomedian and lateral glabellar lobes, fixed and free cheeks, scattered with granules. Occipital ring and spines, genal spines and furrows, very finely granulated.

Discussion. The wide (tr.) inflated frontomedian lobe, the lateral lobes almost confluent with the fixed cheek, and the eye placed opposite the base of 2L would indicate the cephalon belonged to Ceratocephala.

Genus Ceratocephalina Whittington, 1956

Type species. Original designation; Ceratocephala (Ceratocephalina) tridens Whittington 1956, p.243, pl.16, figs.1-24; from the lower Edinburg Limestone (Middle Ordovician), Virginia, U.S.A.

Diagnosis and discussion. See Bruton (1968, p.55).

Ceratocephalina reperta (Reed, 1925) Pl.23, figs.5,8.

v.1925 Acidaspis (Primaspis) reperta Reed, p.70, pl.2, figs.2,2a.

1931a Acidaspis reperta Reed; Reed, p.16.

1938 Primaspis reperta Reed; Whittard, p.111.

1968 Ceratocephalina tricornis (Barrande, 1846); Bruton, p.56.

Holotype. BM In36957, Pl.23, fig.5; figured Reed 1925, pl.2, figs. 2,2a; from Newlands Formation, Locality 14.

Material, locality and horizon. From type locality: BM In42692, YH N625 (Pl.23, fig.8), cranidia.

Diagnosis. Cranidium twice as wide as long. Glabella not greatly inflated, tapering forwards. Longitudinal furrow not deeply impressed. Occipital ring with pair of spines, a median spine, and a pair of granules. 3L not well defined. Fixed cheek narrow. No preglabellar field.

Dimensions of holotype. Sagittal cranidial length, 2.5mm; width of cranidium, 3.7mm.

Description. Cranidium small, gently convex, twice as wide as long. Frontomedian lobe tapering anteriorly to $\frac{3}{4}$ posterior width (tr.), anterior and posterior margins transverse, anteriorly sloping gradually to anterior border furrow. Longitudinal furrow not deeply impressed. Occipital ring 4 times wider (tr.) than long (sag.); with median spine as long as the glabella, 2 small granules either side of median line, and pair of stout occipital spines $1\frac{1}{3}$ times longer than cranidium curving ventrally; with narrow posterior band. Occipital furrow distinct. 1L about $\frac{1}{3}$ length (exsag.) of frontomedian lobe, oval in outline, twice as long (exsag.) as wide (tr.). 2L approximately same outline as 1L but smaller. 3L not clearly defined but distinguishable as projection from frontomedian lobe. 1S deep but not extending as far as axial furrow running forward abaxially. 2S wide and shallow, reaching axial furrow, approximately parallel with 1S. 3S not discernable. Axial furrow deep opposite 1L shallowing anteriorly. Fixed cheek narrow, triangular in outline, widest at posterior border dying out just anterior to 2L. Eye ridge well developed, concentric with fixed cheek, dying out anteriorly opposite anterior limit of frontomedian lobe, posterior limit unknown hence position of palpebral lobe unknown. Anterior section of facial suture deviating only a little from course of eye ridge. Posterior section of facial suture unknown. Anterior border straight and narrow (sag.) but equal to width across 1L lobes. Anterior border furrow very short (sag.). No preglabellar field. All raised surfaces with large granules sparsely distributed.

Discussion. The stout paired and median occipital spines, the posterior band of the occipital ring, the anteriorly tapering frontomedian lobe and the 3 pairs of lateral glabellar lobes all indicate that this form belongs to Ceratocephalina.

Bruton (1968, p.56) considered Acidaspis reperta Reed, 1925 synonymous with C. tricornis (Barrande, 1846) from the Kopanina Beds (Ludlow), Bohemia. However, the present author considers that the Bohemian and Girvan forms are not conspecific. Although the Girvan specimens are much smaller than those figured from Bohemia, reperta differs from tricornis in that 1L is not so inflated nor projects so far posteriorly, the occipital ring and furrow are shorter (sag.), 3L is not so well developed, the anterior border of the cranidium is wider (tr.), only 2 large granules are present on the occipital ring and there are fewer larger granules on the cranidium as a whole.

ADDENDUM

Genus Kosovopeltis Šnajdr, 1958

A paper by Webby (1974, p.203) on the Upper Ordovician trilobites from Central New South Wales has recently been brought to my attention. In it Webby (p.215) erected Heptabronteus a scutelluid he considered to bear a close resemblance to Kosovopeltis but which differed in that it does not have the genal angle prolonged into a spine, has a relatively longer pygidial doublure and has a less inflated and non-trilobed pygidial axis. The present author considers these characters do not warrant generic distinction; 'H'. atavus and 'H'. major (Webby, 1974) can be accommodated in Kosovopeltis. The similarity of the arrangement of the lateral glabellar muscle impression, and the overall disposition of the glabellar lobe, rostral plate, hypostome, thorax and pygidium of Heptabronteus and Kosovopeltis are here considered strong evidence that Heptabronteus is a junior subjective synonym of Kosovopeltis. Webby (Ibid., p.217) includes K. romanovskii (Weber, 1948) in his new genus; but he was apparently unaware that this species is the type species of Eokosovopeltis Přibyl & Vaněk, 1971, which I have also synonymised with Kosovopeltis (see P.21). Webby's species atavus and major are now referred to Kosovopeltis.

K. atavus (Webby, 1974) from the Ordovician of New South Wales, differs from K. cunctatum in that the axial furrows reach further anteriorly and diverge outwards more from opposite the anterior limit of the palpebral lobe, the genal angle is not produced into a spine, there are distinct terrace 'ridges' on the anterior part of the glabella parallel with the anterior edge, and the pygidium is slightly wider and shorter. K. major (Webby, 1974) differs from K. cunctatum in that the fixed cheek is much wider, the cranidial terrace 'ridges' are finer and have a slightly different orientation, the occipital muscle impression is not so well defined and the pygidial doublure reaches further anteriorly. K. andersoni from Girvan differs from the two New South Wales species in that the cranidium has an anterior border, the axial furrow reaches further anteriorly and the pygidial pleurae are carinate.

Bourque, P.-A. & Lespérance, P.J. (1977: The Silurian-Devonian Boundary in the north-eastern Gaspé Peninsula, Quebec. The Silurian-Devonian Boundary. IUGS Series A, No.5, 245-255. Stuttgart) recorded an unnamed species of Kosovopeltis from the lowermost Devonian beds of the Gaspé Peninsula, Quebec, which extends the range of the genus (see Page 22).

STRATIGRAPHICAL AND GEOGRAPHICAL DISTRIBUTION

Silurian sediments of the Girvan area are of three types; conglomerates, sandstones, and graptolitic mudstones and shales. These three rock types laid down in the above order make up a unit which is repeated throughout the area, although the conglomeratic horizon is not always present.

Cocks & Toghill (1973) envisaged that these sediments are relatively immature and are the result of repeated marine transgressions over a continental shelf. However, R. Fowler (pers. comm.) suggests from sedimentary evidence that these units could represent large turbidite flows which have moved from a continental shelf into a deeper water, graptolitic basin. Shelly fossils preserved mostly in the sandstone horizons are mostly disarticulated elements (free cheeks, pygidia, cranidia of trilobites, and the separated valves of brachiopods) but there are the occasional articulated specimens (Pl.5, figs.1a,1b). Many of the disarticulated specimens possess very long and delicate spines (eg. Miraspis ultima Pl.23, figs.7a-c.) which have remained undamaged. From this evidence the fossils are considered not to have moved long distances unless as particles within a suspended sediment flow. Also Cocks & Toghill (1973) recognized distinct brachiopod communities in the fossiliferous horizons. If the fossils had been part of a large turbidite flow then it would be expected that the communities would not be so well defined. Hence, the present author would favour the postulation of repeated marine transgressions over a continental shelf to account for the Silurian sediments in the Girvan area.

Cocks & Toghill (1973) concluded that the brachiopod fauna in the rocks of Silurian age could be compared with the soft-bottom brachiopod communities recognized in the Welsh Borderland and Wales (Ziegler, 1965; Ziegler, Cocks & Bambach, 1968) ie. the Eocoelia, Pentamerus, Stricklandia, and Clorinda communities are present in the Silurian rocks of the Girvan area. Each of these communities is envisaged as representing a life assemblage, in a shallow—shelf sea, occupying an area parallel to the shore line.

In comparison to the well documented brachiopod communities of Wales and the Welsh Borderlands (see above) and other areas, for example the North Esk Inlier of the Pentland Hills (Tipper, 1974), relatively little work has been accomplished to ascertain the relationship of trilobite genera to their environment, to the already well documented brachiopod genera, and to the sediment type. In the last respect it can be noted that in the Silurian rocks of Girvan the sediments enclosing the shallow water community of Eocoelia (or the Cryptothyrella equivalent) are always coarser grained than those enclosing the relatively deeper water communities. Trilobite 'associations' that have already been noted in published literature are mostly confined to the Ordovician (eg. Fortey, 1975; Ross, 1975; Chatterton & Ludvigsen, 1976). Some studies have been made in the Silurian but these are mainly concerned with the Wenlock Series (Lane, 1972; Thomas, 1975).

Fortey (1975) in his work on the Valhallfonna Formation (Arenig-Llanvirn) from Ny Friesland, Spitsbergen, recognized three distinct benthonic trilobite associations. The Nileid and Olenid associations were considered to have occupied regions very close to the edge of the continental shelf, in fact the Olenid assemblage is found in very close association with the graptolitic shales of the deeper part of the basin. The Nileid assemblage is located shoreward of the Olenid assemblage. The third assemblage is considered to be a 'reef' environment located much nearer the shoreline and is characterized by illaenids and cheirurids. No equivalent of the Nileid and Olenid assemblages can be recognized in the Girvan area. An illaenid-cheirurid assemblage can be extrapolated into the Silurian in the ?Wenlock deposits of Konprins Christians Land, N.E. Greenland (Lane, 1972) where scutelluids take the place of some of the illaenids. Although scutelluids and cheirurids are well represented at most localities in Girvan, they are not the dominant forms as they are in the formations of Spitsbergen and Greenland. Encrinurus, Acernaspis and Calymene are the most numerous forms in the Silurian of Girvan. The lack of an 'illaenid'-cheirurid dominated fauna would perhaps confirm that the Girvan Llandovery fossiliferous deposits represent a soft-bottom, non-reef environment. It is conceivable that the reef environment of the 'illaenid'-cheirurid assemblage would have occupied a similar position on the shelf as the Clorinda and Stricklandia communities of Girvan as in the latter two communities the 'illaenid'-cheirurid element is relatively high.

Chlupáč (1975) has shown that during the Silurian the occurrences of Acernaspis were mainly concentrated in shallow water deposits. The presence of Acernaspis in the Silurian sediments of the Girvan area (except for Locality 24 which has Wenlock affinities) suggests that the Girvan fauna was originally deposited in a shallow-shelf sea.

The Craighead Inlier. The lowest formation of the Silurian of the Craighead Inlier is the Lady Burn Conglomerate which has a very small fossil content (Cocks & Toghill 1973, p.213) and is overlain by the very fossiliferous Mulloch Hill Formation. The oldest fossiliferous unit of the Mulloch Hill Formation (Localities 1-7) has been referred to a Cryptothyrella (the equivalent of Eocoelia) community (Cocks & Toghill 1973, p.213) and hence is regarded to have been deposited in relatively shallow water. The main trilobites are Acernaspis cf. A. elliptifrons, Calymene subdiademata subdiademata, Astroproetus scoticus and Cyphoproetus externus (Diversity Index = 4.76). A higher unit in the Mulloch Hill Formation (Localities 8 and 9) perhaps represents deposition in marginally deeper water because of the higher diversity of the general fauna. It has a trilobite fauna dominated by Calymene subdiademata subdiademata with the other prominent forms being Opsypharus maccallumi, Acernaspis cf. A. elliptifrons and Encrinurus squarrosus (Diversity Index = 6.81). The youngest fossiliferous unit of the Mulloch Hill Formation (Locality 10) is considered to represent a Clorinda community (Cocks & Toghill 1973, p.214). At this locality Encrinurus squarrosus, Cyphoproetus externus, Acernaspis xynon, Calymene subdiademata subdiademata and Harpidella newlandensis are dominant. This fauna presumably represents a distinct change of environment of deposition from Localities 1-9 related to an increase in depth of water. Encrinurus squarrosus has replaced Calymene subdiademata subdiademata as the dominant form and Acernaspis cf. A. elliptifrons has been replaced by A. xynon. The latter two species of *Acernaspis* although confined to a shallow-shelf sea (Chlupáč, 1975) probably are representative of a division of the shelf area. The former is probably indicative of a near shore environment whereas the latter occupies a position closer to the edge of the shelf. The Mulloch Hill Formation is overlain by the graptolitic Glenwells Shale possibly representing the completion of a marine transgression (see P.172). The Glenwells Shale is overlain by the unfossiliferous Glenwells conglomerate which is succeeded by the Newlands Formation. The oldest fossiliferous localities in the Newlands Formation are Localities 11-13 which are considered by Cocks & Toghill (1973, p.215) to show *Stricklandia* community elements. *Acernaspis superciliexcelsis*, *Calymene subdiademata subdiademata* and *Encrinurus squarrosus* dominate at these localities. *A. superciliexcelsis* is morphologically very similar to *A. xynon* and therefore also representative of an off-shore environment. The youngest fossiliferous localities in this formation are Localities 14 and 15. These localities have a highly diverse general fauna referred by Cocks & Toghill (1973, p.216) to a *Clorinda* community. The same three forms listed above for Localities 11-13 are dominant here also. Twenty species of trilobites are present at Locality 14 (Diversity Index = 9.00) and many of these are peculiar to that locality (eg. *Globulaspis prominens*, *Ceratocephalina reperta*, *Miraspis ultima*, *Encrinurus*? *muldooni*). The Newlands Formation is overlain by the graptolitic Glenshalloch Shale representing possibly the conclusion of another marine transgression. The succeeding Upper Saugh Hill Grits have yielded no fossils; it is overlain by the graptolitic Pencleuch Shale. The final fossiliferous formation in the Craighead Inlier is the Lower Camregan Grits in which Localities 16 and 17 are considered by Cocks & Toghill (1973, p.218) to represent a *Pentamerus/Eocoelia* community. These localities have a small trilobite fauna dominated by *Harpidella* aff. *H. newlandensis* and *Acernaspis* sp. A, with a diversity index of 4.15. *Acernaspis* sp. A is morphologically similar to *Acernaspis* cf. *A. elliptifrons* found in what is here considered to be the shallower water, near-shore deposits of the Mulloch Hill Formation (see above).

<u>The Coastal Section</u>. The oldest Silurian formation in the coastal sequence at Woodland Point is the unfossiliferous Craigskelly Conglomerate which is overlain by the fossiliferous Woodland Formation. Brachiopod studies of the older part of this Formation (Locality 18) shows that this is of the relatively deep <u>Stricklandia/Clorinda</u> community. Like the Newlands Formation, which was possibly deposited at a similar depth, the dominant trilobites are <u>Encrinurus squarrosus</u>, <u>Calymene subdiademata subdiademata</u> and <u>Acernaspis superciliexcelsis</u>. This locality, like that of Locality 14 in the Newlands Formation, has a highly diverse trilobite fauna (Diversity Index = 9.26) and could be considered to represent similar environmental conditions in separate parts of the area at slightly different times. The younger unit of the Woodland Formation is a graptolitic shale presumably representing the termination of another transgressive period before the deposition of the unfossiliferous Scart Grits and Quartz Conglomerate.

<u>The Main Outcrop</u>. The older formations of the Main Outcrop (Tralorg Formation, Saugh Hill Grits and Pencleuch Shale), apart from graptolitic shales, are unfossiliferous and it is the Lower Camregan Grits which provide the first 'shelly' fossils. Fossiliferous horizons in this Formation (Locality 19) are full of <u>Eocoelia curtisi</u> indicating an <u>Eocoelia</u> community. The dominant trilobites are <u>Astroproetus pseudolatifrons</u>, <u>Acernaspis</u> sp. A and <u>Encrinurus confusevarus</u> (Diversity Index = 3.41). <u>Acernaspis</u> sp. A as seen above is considered to be a near-shore, shallow water form. The Lower Camregan Grits is overlain by the Wood Burn Formation. Cocks & Toghill (1973, p.226) show that the base of this Formation has <u>Pentamerus</u> community elements which grade upwards into <u>Clorinda</u> community fauna of Localities 20 and 21. At these localities the dominant trilobites are <u>Encrinurus mullochensis</u>, <u>Acernaspis woodburnensis</u> and <u>Bumastus? vulsus</u>. Throughout the Main Outcrop calymenids are rare. Locality 22 (Penkill) presumed also to be in the Wood Burn Formation (see P.12 for discussion) has a peculiar trilobite fauna dominated by <u>Youngia trispinosa</u> with

Encrinurus mullochensis, Kosovopeltis andersoni and Stenopareia catathema also present (Diversity Index = 4.27). If Locality 22 has been correctly located it appears to have no affinities in trilobite fauna with Localities 20 and 21 situated to the east and west of Locality 22 and probably represents an isolated pocket of differing environmental conditions to those of Localities 20 and 21. Locality 23 ('Penwhapple Glen' of Mrs Gray) is placed in the Lauchlan Formation (see P.12 for details) but the lack of knowledge of its precise location and the relatively few specimens render its comparison with other localities difficult. The remainder of the western part of the Main Outcrop consists of series of unfossiliferous sandstones and graptolitic shales and mudstones.

To the east in the Blair and Knockgardner area the Drumyork Flags are followed by the graptolitic Blair Shales. These shales are overlain by thinly bedded turbidites of the Knockgardner Formation which carry a Howellella/Protochonetes brachiopod assemblage. This assemblage and the large number of ostracods present is considered to be indicative of fairly shallow water conditions (Cocks & Toghill 1973, p.239). Certainly the small trilobite fauna of only 5 species is different from anything older. It is unknown if the low diversity of the trilobite fauna (Diversity Index = 2.17) is related to depth or a general change in environmental conditions as this Formation is followed by the Straiton Grits which contains a basal member which has a fauna of bivalves and ostracods probably constituting a brackish or fresh water assemblage (Cocks & Toghill 1973, p.239).

From the Faunal Lists (see below) it can be noted that the diversity indices of the trilobite fauna increases with the presumed relative increase in water depth. The very shallow brackish or fresh water fauna of Locality 24 has a very low index of 2.17, then the index gradually increases from the Eocoelia community (on average 4.7) through to the Clorinda community (on average 8.0). This increase of the index with depth reflects a similar trend of the general fauna of lower Silurian marine communities (Ziegler, Cocks & Bambach, 1968).

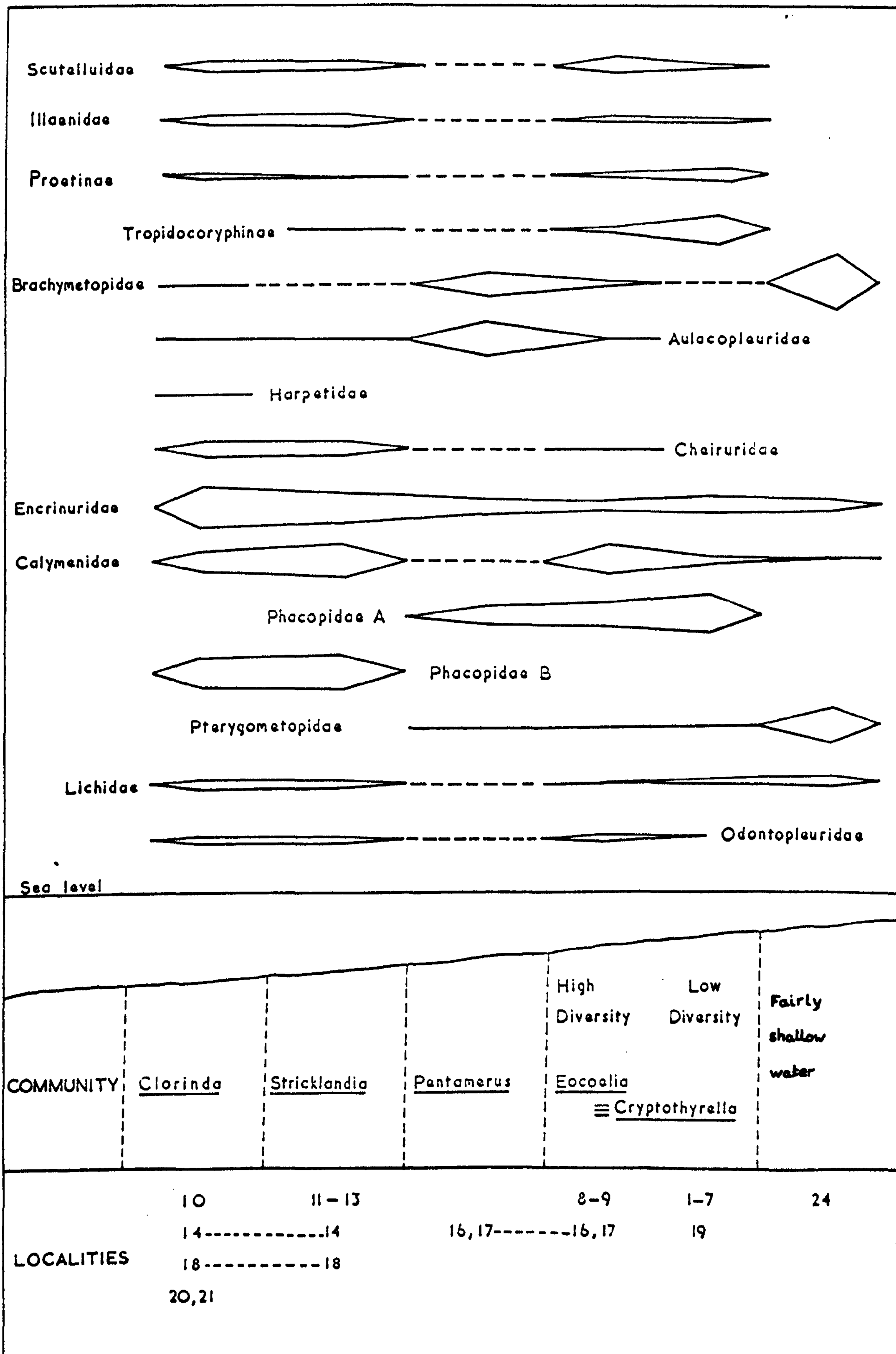
A general distribution of trilobite taxa in relation to the brachiopod communities described above is given in Text-fig.40. The diagram would seem to suggest that the Scutelluidae, Cheiruridae and Encrinuridae have a preference for slightly deeper water, off-shore conditions equivalent to a Clorinda or Stricklandia community. Podowrinella, the sole representative of the Pterygometopidae can be seen to be a very shallow water form. Acernaspis is the only genus in which we can distinguish definite near-shore and off-shore forms.

The species of trilobite in the gregarius and older zones differ completely from those in the sedgwickii and younger zones (Text-fig.41). The reason for this change of fauna when soft-bottom conditions returned again after the Pencleuch Shale is unknown. There is no evidence that the convolutus Zone was of a length to have allowed such a progression in evolution. For some reason the last gregarius Zone marine transgression caused the disappearance of the well established species already in existence. Recolonization of the area during the sedgwickii Zone must have been from another stock of trilobites different to those which had colonized in the pre-convolutus Zone period. We have no knowledge of possible directions of colonization because of the lack of preservation of contemporary fauna in the Silurian Inliers of the Southern Uplands. The only other group of fossils from the Silurian of Girvan to be studied in any detail is the Brachiopoda but it can provide no evidence for the behaviour of the trilobite species.

The other Silurian Inliers in the Midland Valley of Scotland have rocks which are correlated with the late Llandovery or early Wenlock Series. Podowrinella straitonensis and Hemiarges rolfei found in the Knockgardner Formation of Girvan occur also in the Ree Burn Formation of the Hagshaw Hills and the Wether Law Linn Formation of the North Esk Inlier

TEXT-FIG.40. Diagram to show the relative abundances of trilobite families or subfamilies from the Silurian rocks of Girvan in relation to the assumed brachiopod communities (Cocks & Toghill, 1973).

The Phacopidae has been divided into two units representing shallow, near-shore forms and deeper water, off-shore forms, Phacopidae A and Phacopidae B respectively.



Scutelluidae
Illaenidae
Proetinae
Tropidocoryphinae
Brachymetopidae
Aulacopleuridae
Harpetidae
Cheiruridae
Encrinuridae
Calymenidae
Phacopidae A
Phacopidae B
Pterygometopidae
Lichidae
Odontopleuridae
Sea level
High Diversity
Low Diversity
Fairly shallow water
COMMUNITY
Clorinda
Stricklandia
Pentamerus
Eocoelia
≡ Cryptothyrella
LOCALITIES
10
14 ------------ 14
18 ----------- 18
20, 21
11 – 13
16, 17 ------- 16, 17
8–9
1–7
19
24

of the Pentland Hills (see Clarkson et al., 1977, text-fig.1).

The Llandovery deposits of Haverfordwest, the Haverford Mudstone Formation (Rhuddanian) in particular (Cocks & Price, 1975), would seem to have some affinity to the Girvan fauna. However, except for recent descriptions of some trilobite species the Haverfordwest fauna is in need of revision. Recent descriptions show that Hadromeros elongatus is common to both fauna. A form very close to or conspecific with Stenopareia thomsoni is also dominant at Haverfordwest. A Harpidella form and a Lichas form from Haverfordwest are similar to the Harpidella and Lichas species of Girvan. However, detailed work on calymenids by Siveter (1973) showed that the calymenid forms found in the two areas are generically distinct.

The small trilobite fauna of Meifod (Temple, 1970) does not compare closely with that of Girvan and its affinities may be found to lie nearer to the Haverfordwest fauna.

The Llandovery fauna from the Pentamerus Beds (Fronian) and Purple Shales (Telychian) from Shropshire (Whittard, 1938) has no species in common with Girvan. However, Opsypharus maccallumi, Stenopareia acymata sp. nov., Cyphoproetus pugionis sp. nov., Harpidella newlandensis, and Lichas silvestris of Girvan show similarities to Illaenus arenaceus, Stenopareia aemula, Cyphoproetus binodosus, Harpidella elegantula and 'Lichas marginatus' respectively, as described by Whittard 1938.

The trilobites of the Llandovery area itself have yet to be described although a summary of forms is given in Lane 1968 (unpublished Ph.D. thesis).

It is difficult to compare the Girvan Silurian trilobite fauna with any other outside the British Isles as no fauna of this age has been comprehensively described. However, some Girvan genera can be seen to occur in various Silurian fauna. Kosovopeltis and Acernaspis are found in the Henryhouse Formation (Upper Wenlock - Early Ludlow), Oklahoma, U.S.A. The Cape Schuchert Formation (Llandovery), Cape Schuchert, North Greenland, contains Kosovopeltis and an Encrinurus form similar to Encrinurus?

muldooni sp. nov. from Girvan. There is also generic similarity with the A4/B1 trilobite fauna of Hall Land, North Greenland (P. D. Lane, pers. comm.). Various other Girvan forms compare closely with single species from other countries (see *Kosovopeltis cunctatum* compared with *K. estonicum* (Schmidt, 1894) from the lower Silurian of Estonia ; *K. andersoni* compared with *K. parvispina* Šnajdr, 1960 from the Kopanina Formation (Ludlow) of Kosov, Czechoslovakia; *Decoroproetus farragatus* sp. nov. compared with *D. campanulatus* Owens 1973 from the Ordovician of Scandinavia; *Warburgella (Warburgella) capetos* sp. nov. compared with *W. (Warburgella) baltica* Alberti, 1963, from the Llandovery or Early Wenlock of Lummelunda, Gotland, Sweden; *Encrinurus? muldooni* sp. nov. compared with *E. tuberculifrons* Weller 1907, from the Wenlock of Illinois.).

FAUNAL LISTS

Faunal lists of both general (Cocks pers. comm.) and trilobite species are given for each locality. The assumed brachiopod community (Cocks & Toghill, 1973) for each locality is indicated.

For the purpose of calculation, the number of individuals has been taken from the number of the most abundant part of each species represented in each collection. This has been converted into relative abundance expressed as a percentage (n represents the number of individuals).

The Diversity Index of the trilobite species is given for each locality (D. I. = number of species of trilobite / $\log_e$ number of individuals).

Localities 1-7. Mulloch Hill Formation. Low diversity *Cryptothyrella* community.

General fauna			n=229
brachiopods	51	corals	5
gastropods	26	bivalves	2
crinoids	13	*Tentaculites* sp.	1

polyzoans	1	trilobites	1

Trilobite fauna D.I.=4.76 n=117

Acernaspis cf. A. elliptifrons	48	Hemiarges serus	2
Calymene subdiademata subdiademata	18	Platylichas scoticus	1
Astroproetus scoticus	13	Encrinurus squarrosus	1
Cyphoproetus externus	10	Leonaspis sp. B	1
Opsypharus maccallumi	3	Hemiarges hypostome C	1
Stenopareia thomsoni	2		

Localities 8 and 9. Mulloch Hill Formation. High diversity Cryptothyrella community.

General fauna n=255

brachiopods	67	trilobites	4
corals	12	gastropods	3
polyzoans	6	crinoids	2
Mastopora fava	5	bivalves	1

Trilobite fauna D.I.=6.81 n=223

Calymene sudiademata subdiademata	45	Anacaenaspis callipareos	2
Opsypharus maccallumi	14	Cyphoproetus externus	1
Acernaspis cf. A. elliptifrons	13	Leonaspis sp. B	0.2
Encrinurus squarrosus	8	Deiphon sp.	0.2
Platylichas scoticus	4	Lichas silvestris	0.2
Stenopareia thomsoni	4	Stenopareia glochin	0.2
Hemiarges serus	3	Leonaspis sp. D	0.2
Leonaspis cf. L. deflexa	3	Hemiarges hypostome A	0.2

Locality 10. Mulloch Hill Formation. Clorinda community.

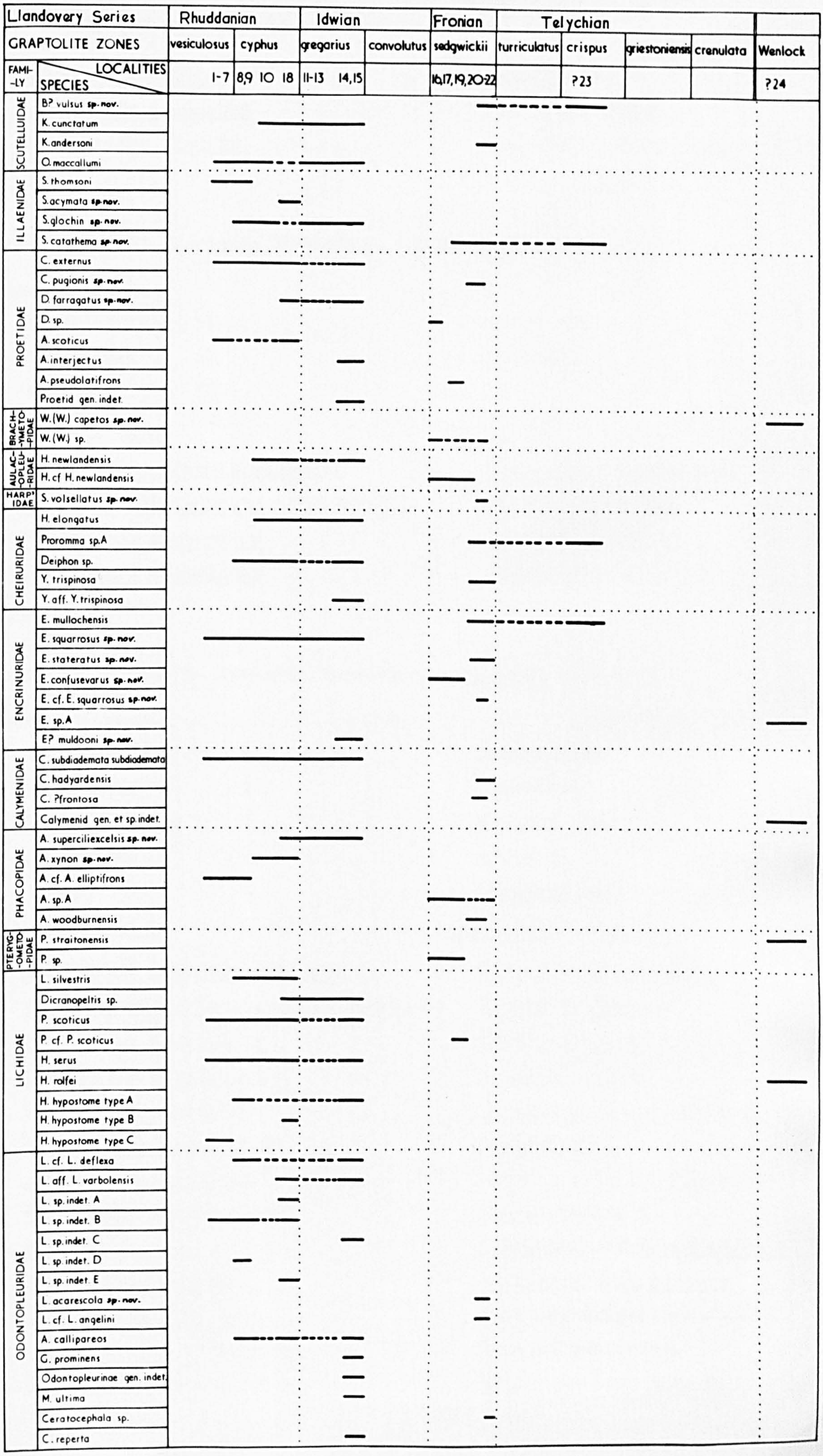
General fauna n=119

brachiopods	60	crinoids	3
polyzoans	13	gastropods	2
trilobites	8	Tentaculites	2
corals	8	Conularia spp	1
bivalves	3		

Trilobite fauna D.I.=6.90 n=55

Encrinurus squarrosus	23	Calymene subdiademata subdiademata	9
Cyphoproetus externus	19	Harpidella newlandensis	9
Acernaspis xynon	17	Kosovopeltis cunctatum	7

TEXT-FIG.41. Diagram to show the stratigraphical ranges of the Silurian trilobite species found in the Girvan area. Graptolite zones are used to divide the Llandovery Series.


Llandovery Series
Rhuddanian
Idwian
Fronian
Telychian
GRAPTOLITE ZONES
vesiculosus
cyphus
gregarius
convolutus
sedgwickii
turriculatus
crispus
griestoniensis
crenulata
Wenlock
FAMI-LY
LOCALITIES
SPECIES
1-7
8,9 10 18
11-13 14,15
16,17,19,20-22
?23
?24
SCUTELLUIDAE
B? vulsus sp. nov.
K. cunctatum
K. andersoni
O. maccallumi
ILLAENIDAE
S. thomsoni
S. acymata sp. nov.
S. glochin sp. nov.
S. catathema sp. nov.
PROETIDAE
C. externus
C. pugionis sp. nov.
D. farragatus sp. nov.
D. sp.
A. scoticus
A. interjectus
A. pseudolatifrons
Proetid gen. indet.
BRACH-YMETO-PIDAE
W. (W.) capetos sp. nov.
W. (W.) sp.
AULAC-OPLEU-RIDAE
H. newlandensis
H. cf H. newlandensis
HARP-IDAE
S. volsellatus sp. nov.
CHEIRURIDAE
H. elongatus
Proromma sp. A
Deiphon sp.
Y. trispinosa
Y. aff. Y. trispinosa
ENCRINURIDAE
E. mullochensis
E. squarrosus sp. nov.
E. stateratus sp. nov.
E. confusevarus sp. nov.
E. cf. E. squarrosus sp. nov.
E. sp. A
E? muldooni sp. nov.
CALYMENIDAE
C. subdiademata subdiademata
C. hadyardensis
C. ?frontosa
Calymenid gen. et sp. indet.
PHACOPIDAE
A. superciliexcelsis sp. nov.
A. xynon sp. nov.
A. cf. A. elliptifrons
A. sp. A
A. woodburnensis
PTERYG-OMETO-PIDAE
P. straitonensis
P. sp.
LICHIDAE
L. silvestris
Dicranopeltis sp.
P. scoticus
P. cf. P. scoticus
H. serus
H. rolfei
H. hypostome type A
H. hypostome type B
H. hypostome type C
ODONTOPLEURIDAE
L. cf. L. deflexa
L. aff. L. varbolensis
L. sp. indet. A
L. sp. indet. B
L. sp. indet. C
L. sp. indet. D
L. sp. indet. E
L. acarescola sp. nov.
L. cf. L. angelini
A. callipareos
G. prominens
Odontopleurinae gen. indet.
M. ultima
Ceratocephala sp.
C. reperta

Lichas silvestris	5	*Deiphon* sp.	1
Hadromeros elongatus	5	*Hemiarges serus*	1
Stenopareia glochin	4	*Opsypharus maccallumi*	1

Localities 11-13. Newlands Formation. *Stricklandia* community.

General fauna n=87

brachiopods	58	polyzoans	9
trilobites	12	ostracods	9
crinoids	12		

Trilobite fauna D.I.=4.25 n=76

Acernaspis superciliexcelsis	30	*Kosovopeltis cunctatum*	8
Calymene subdiademata subdiademata	29	*Dicranopeltis* sp.	1
Encrinurus squarrosus	19	*Hadromeros elongatus*	1
Opsypharus maccallumi	11	*Stenopareia glochin*	1

Localities 14 and 15. Newlands Formation. *Clorinda* community.

General fauna n=357

brachiopods	53	graptolites	3
trilobites	19	bryozoans	3
Mastopora fava	9	*Tentaculites* sp.	2
gastropods	4	crinoids	2
corals	4	*Conularia* sp.	1

Trilobite fauna D.I.=9.00 n=1031

Acernaspis superciliexcelsis	26	*Stenopareia glochin*	1.5
Calymene subdiademata subdiademata	24	*Dicranopeltis* sp.	1.5
Encrinurus squarrosus	21	*Ceratocephalina reperta*	1.5
Opsypharus maccallumi	8	*Miraspis ultima*	1.5
Hadromeros elongatus	7	*Anacaenaspis callipareos*	1.5
Kosovopeltis cunctatum	4	*Deiphon* sp.	1.5
Cyphoproetus externus	2	*Youngia* aff. *Y. trispinosa*	1.5
Harpidella newlandensis	1	*Leonaspis* sp. C	0.5
Hemiarges serus	1	*Leonaspis* aff. *L. varbolensis*	0.5
Encrinurus? *muldooni*	1	*Leonaspis* cf. *L. deflexa*	0.5
Globulaspis prominens	1	Odontopleurinae gen. indet.	0.5
Decoroproetus farragatus	1	Proetid gen. indet.	0.5
Astroproetus interjectus	1	*Hemiarges* hypostome A	0.5

Localities 16 and 17. Lower Camregan Grits. Eocoelia/Pentamerus community.

General fauna n=113

brachiopods	64	polyzoans	5
trilobites	13	gastropods	3
corals	7	Tentaculites spp	3
crinoids	5	Cornulites spp.	2

Trilobite fauna D.I.=4.15 n=27

Harpidella aff. H. newlandensis	39	Encrinurus confusevarus	11
Acernaspis sp. A	25	Podowrinella sp.	3
Warburgella sp.	18	Decoroproetus sp.	3

Locality 18. Woodland Formation. Stricklandia/Clorinda community.

General fauna not systematically itemized but very similar to localities 14 and 15.

Trilobite fauna D.I.=9.26 n=179

Encrinurus squarrosus	28	Astroproetus scoticus	1
Acernaspis xynon	14	Leonaspis aff.L.varbolensis	1
Calymene subdiademata subdiademata	12	Anacaenaspis callipareos	1
Acernaspis superciliexcelsis	12	Hemiarges serus	0.5
Hadromeros elongatus	7	Harpidella newlandensis	0.5
Stenopareia acymata	7	Leonaspis sp.A	0.5
Kosovopeltis cunctatum	6	Leonaspis sp.B	0.5
Lichas silvestris	2	Leonaspis sp.E	0.5
Hemiarges hypostome Type B	2	Deiphon sp.	0.5
Platylichas scoticus	1	Cyphoproetus externus	0.5
Dicranopeltis sp.	1	Decoroproetus farragatus	0.5

Locality 19. Lower Camregan Grits. Eocoelia community.

General fauna n=137

brachiopods	68	gastropods	5
Tentaculites spp	8	trilobites	4
crinoids	7	polyzoans	3
bivalves	5		

Trilobite fauna D.I.=3.41 n=113

Astroproetus pseudolatifrons	46	Stenopareia catathema	3
Acernaspis sp. A	34	Harpidella aff.H.newlandensis	2
Encrinurus confusevarus	13	Platylichas cf.P.scoticus	1

Podowrinella sp. A 1

Locality 20. Wood Burn Formation. Clorinda community.

General fauna not itemized but containing about 26 species of brachiopod, with gastropods, corals, crinoids, bivalves and graptolites.

Trilobite fauna D.I.=5.88 n=23

Encrinurus mullochensis	26	Stenopareia catathema	9
Bumastus? vulsus	22	Encrinurus stateratus	9
Acernaspis woodburnensis	17	Cyphoproetus pugionis	4
Proromma sp.	9	Youngia trispinosa	4

Locality 21. Wood Burn Formation. Clorinda community.

General fauna not itemized but as for Locality 20.

Trilobite fauna D.I.=7.73 n=95

Encrinurus mullochensis	33	Cyphoproetus pugionis	3
Acernaspis woodburnensis	25	Scotoharpes volsellatus	2
Bumastus? vulsus	11	Leonaspis aff.L.angelini	2
Encrinurus cf.E.squarrosus	5	Leonaspis acarescola	2
Encrinurus stateratus	5	Stenopareia catathema	2
Proromma sp.	4	Warburgella sp.	1
Kosovopeltis andersoni	4	Calymene ?frontosa	1

Locality 22. Wood Burn Formation. Clorinda community.

General fauna not itemized because not now collectable, and specimens already collected widely dispersed throughout museums.

Trilobite fauna D.I.=4.27 n=128

Youngia trispinosa	25	Encrinurus stateratus	5
Encrinurus mullochensis	22	Bumastus? vulsus	4
Kosovopeltis andersoni	19	Calymene hadyardensis	2
Stenopareia catathema	16	Ceratocephala sp.	1
Acernaspis sp. A	6		

Locality 23. ?Lauchlan Formation.

General fauna not itemized as position of locality uncertain and museum collections too widely dispersed.

Trilobite fauna too small to give comparative percentages but contains:- Bumastus? vulsus, Stenopareia catathema, Proromma sp., Encrinurus mullochensis.

Locality 24. Knockgardner Formation. Very shallow water.

General fauna n=133

brachiopods	69	*Cornulites* spp.	3
polyzoans	9	crinoids	2
trilobites	8	bivalves	2
ostracods	5	gastropods	1

Trilobite fauna D.I.=2.17 n=203

Warburgella (*Warburgella*) *capetos*	53	*Hemiarges rolfei*	7
Podowrinella straitonensis	30	Calymenid gen.et sp.indet.	1
Encrinurus sp.	9		

Percentage trilobite fauna collected from 4 turbidite horizons (see Text-fig.17)

Horizon	1K	2K	3K	4K
W. (*Warburgella*) *capetos*	48	71	54	46
P. straitonensis	28	17	28	36
Encrinurus sp.	14	4	11	9
H. rolfei	10	8	7	9
n	21	24	92	11

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APPENDIX I

Trilobite Species

Neontologists often try to define a species as an interbreeding population in which the individuals have a similar behaviour pattern, physiology, genetic structure, biochemistry and, incidentally, similar morphology. In practice, however, biological species, in the majority of cases, are delimited by their morphology. This is fortunate for the palaeontologist for whom most biological infomation has been lost due to non-preservation and erosion.

Herein trilobite species are thought to approximate to populations of genetically related individuals if carefully delimited by morphological distinction and stratigraphical isolation from other populations, to account for variation in time, a problem hardly met by biologists.

In erecting new species a palaeontologist often sets himself a set of arbitrary parameters which the proposed species must satisfy, eg. he must have at least 100 specimens, measurements of a particular feature must not vary by a stated amount.

The present author considers that for the case of trilobites at least, the following considerations must be observed before a new species can be established. The proposed species must have more than one feature, and preferably many, which distinguish it from any other form. A species based on only one differing feature may in fact be indicative of a variation caused by adaptation to a particular stimulus. Two very similar forms found in the same bed must be critically examined to determine if they represent sexual dimorphs of one species. Care must also be taken to ensure that similar forms are not extreme members of distortion (L and W forms, see Pages 7,104-108). The number of specimens available should be greater than unity and they should reveal at least 70% of the total exoskeleton of the trilobite, eg. the hypostome and the thorax may be missing, so long as those parts preserved differ sufficiently enough from other known forms to set them apart as a new species. However, a palaeontologist who has spent sometime working on a particular group may feel confident enough to establish a new species on a series of only cranidia or pygidia. Fellow palaeontologists can either accept or reject the species depending on their regard for the proficiency of the worker.

Some fossil groups, eg. brachiopods and ostracods, are most often found in great profusion at localities and so it is easily discerned if there is one species present with a large variation range or many distinct species. However, trilobite workers almost never have a large population in comparison and have to guess whether they are seeing one or more species.

This paucity of specimens renders it almost impossible to detect morphological changes laterally or vertically in one particular species as is often the case with brachiopod species. The trilobite worker is fortunate in this respect in that he does not often have the very difficult task of delimiting or not an evolving species. The majority of trilobite species can be limited with definite end members.

If an evolutionary change can be identified in a trilobite species then the whole range should be classed under one species name. However, where the 'evolved' form is in a different horizon from the 'original' form they are likely to have been given differing species names by previous workers. The palaeontologist has then to consider the advantage of synonymising the two forms or keeping them separate if they are well established names.

Attempts have been made to erect species by numerical methods but these have enjoyed only a limited success. This is probably because the relative weighting of the various morphological features is not taken into account. Statistically a feature is either present or absent ie. 1

or O. To try to give gradational values causes complications in programming and a very diverse classification. The human eye and mind is probably far better at judging group forms.

Unfortunately in trilobite genera whose members have a wide variety of morphological features, eg. Encrinurus with tubercles, there is a tendancy to split the group into smaller units based on small changes of these features but which in truth may not be a specific difference. Genera with very few features, eg. Stenopareia, tend to have fewer species attributed to them as it is so difficult to distinguish changes. Features that change with time should be considered for delimiting species but it is not always possible to detect these. All palaeontologists must be guilty of 'splitting' and 'lumping' at the wrong time although who is qualified to challenge their decision.

In general, in all groups of trilobites, species are distinguished from each other in the relative length and width measurements and shape of the various articulated units, the number of thoracic segments and pygidial ribs, the convexity of various parts, and the sculpture of the exoskeleton. It should be noted that internal moulds often show much deeper and wider furrows and smaller granules than the exoskeleton. Hence, a species should not be established on these criteria alone if only internal moulds are available. In addition to the features above it appears that different trilobite groups have other particular features which are used to separate species.

Illaenacea: Cephalic and pygidial muscle impressions,
Limit of cephalic axial furrow.
Presence or absence of anterior pit of cranidium.
Pattern of terrace 'ridges'.
Form of rostral plate.
Length, and shape of anterior margin, of pygidial doublure.

Proetidae: Shape of glabella.
Presence or absence of preglabellar field, tropidium and pygidial border.

Shape of preglabellar field.
Shape and position of eye socle.

Harpetidae: Position of eye.
Shape of brim and prolongations.

Cheiruridae: Shape and size of glabellar lobes.
Size and position of eye.
Number, form, size and position of pygidial spines.

Encrinuridae: Size and shape of lateral glabellar lobes.
Number, position and size of tubercles on various parts of exoskeleton, eg. glabellar lobe, axial pygidial rings.
Presence or absence of genal spine and longitudinal median furrow.

Calymenidae: Shape of glabellar lobe.
Size and shape of lateral glabellar lobes.
Length and form of preglabellar field and anterior border of cephalon.

Phacopidae: Position and size of glabellar furrows.
Size and lens formula of eye.
Form of vincular furrow.

Lichidae: Size and shape of frontomedian glabellar lobe, bullar lobe and occipital lobe.

Odontopleuridae: Size and shape of lateral glabellar lobes.
Position of eye and eye ridge.
Number and form of spines on various parts of exoskeleton.

In this work there are many forms which have been left under open nomenclature. This is because the author considers that the form is probably different from any other but has not enough well preserved specimens on which to base a new species.

APPENDIX II

Synonymy Lists and Richter Symbols

In the compilation of the synonymy lists herein, selected Richter symbols (Richter, 1948) have been employed. The value of these symbols in annotating synonymy lists has been recognised mainly by German palaeontologists but they have received little attention from British workers despite a paper on their use by Matthews (1973). As pointed out by Matthews (1973, p.718) inclusion of Richter symbols render the lists as critical and detailed pieces of scientific work. A synonymy list complete with Richter symbols conveys the fullest information possible concerning the author's research and subsequent findings into previous publications of the named species in question. A subsequent worker should consider it unnecessary to have to repeat research into any items included in a dependable annotated list. The symbols employed herein are those listed and described by Matthews (1973, p.718) as being those Richter symbols most frequently in use. The symbols are not defined herein but see Matthews (1973, p.718)

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APPENDIX III

Anacaenaspis callipareos Syntypes.

In the quest for the syntypes of *Anacaenaspis callipareos* Thomson (1857, pl.6, fig.11,12) the collections of the following institutions were searched by the author:-

British Museum (Natural History), London
I.G.S., London
I.G.S., Edinburgh
Royal Scottish Museum, Edinburgh
Birmingham University Museum
Grant Institute of Geology Museum, Edinburgh
Hunterian Museum, Glasgow

The curators of the following institutions reported that the syntypes were not in their collections:-

Oxford University Museum
National Museum of Ireland, Dublin
Ulster Museum, Belfast
Queen's University, Belfast
Royal College of Science, Dublin

PLATES

Except where otherwise stated the photographs are of the external surface of the exoskeleton. White latex liquid rubber mixed with black drawing ink was used extensively to produce casts of external moulds which could then be photographed. Before photographing all specimens were given a light dusting of ammonium chloride sublimate, some having previously received a thin coat of dilute matt black opaque to produce more even contrast. A very few small specimens were photographed with a scanning electron microscope and were coated with a thin film of gold-palladium (Pl.8, figs.3,15; Pl.22, fig.2; Pl.23, figs.5,8). None of the negatives or prints have been retouched.

All the photographs are by the author except for those listed below:-

Pl.1, fig.15; Pl.2, figs.8-15; Pl.3, figs.1-14; Pl.7, fig.10. (courtesy of Dr P. D. Lane).

Pl.5, fig.1a. (courtesy of Mr W. J. Baird and Mr G. Holliday)

Camera used by the author:- Alpa Reflex 9d with Ken-Macro-Sivitar f 1.8; 50mm lens.

PLATE 1 continued

Fig. Page

Kosovopeltis _andersoni_ (Etheridge & Nicholson, 1879) 27

Wood Burn Formation, Locality 22 (Penkill).

15. Lectotype cranidium with 9 thoracic segments, internal mould, dorsal view. Figured Nicholson & Etheridge 1879, pl.12, fig.5. HM A138.

16. Pygidium, internal mould, dorsal view. Figured Reed 1906, pl.12, fig.9. On same slab as Fig.13. BM In22652b.

17. Paralectotype pygidium, internal mould, dorsal view. One of the specimens from which Nicholson & Etheridge 1879, pl.12, fig.3 was drawn. BM In22650.

Fig.		Page
	Kosovopeltis cunctatum (Reed, 1931)	23

Newlands Formation, Locality 14 (Newlands Farm)

1. Latex rubber cast of external mould of cranidium, dorsal view. YH NW422a.

3. Free cheek, internal mould, dorsal view. HM A5717.

4. Paralectotype cranidium, internal mould, dorsal view. Figured Reed 1931, pl.4, fig.1. HM A1061.

5. Latex rubber cast of external mould of cranidium, dorsal view. BM It9109.

7. Lectotype cranidium, internal mould, dorsal view. Figured Reed 1931, pl.4, fig.2. HM A1062.

8. Latex rubber cast of external mould, incomplete cranidium, dorsal view. YH NW420a.

9a-c. Hypostome; 9a internal mould, dorsal view, 9c internal mould, lateral view, 9b latex rubber cast of external mould, dorsal view. YH NW450.

10. Paralectotype pygidium, internal mould, dorsal view. Figured Reed 1931, pl.4, fig.3. HM A1063.

11. Latex rubber cast of external mould of pygidium, dorsal view. HM A5828b.

12a,b. Pygidium; 12a internal mould, dorsal view, 12b latex rubber cast of external mould, dorsal view. BM In22659.

13. Paralectotype pygidium, internal mould dorsal view. Figured Reed 1931, pl.4, fig.4. HM A1064.

Newlands Formation, field section midway between Localities 8 and 14.

2. Cranidium, internal mould, dorsal view. HM A1142.

Newlands Formation, Locality 11.

6a,b. Free cheek, internal mould with doublure revealed; 6a dorsal view, 5b enlargement of eye. HM A1140.

Kosovopeltis andersoni (Etheridge & Nicholson, 1879) 27

Wood Burn Formation, Locality 22 (Penkill)

14. Cranidium, incomplete internal mould, dorsal view. Figured Reed 1906, pl.12, fig.11. BM In22652c.

PLATE I

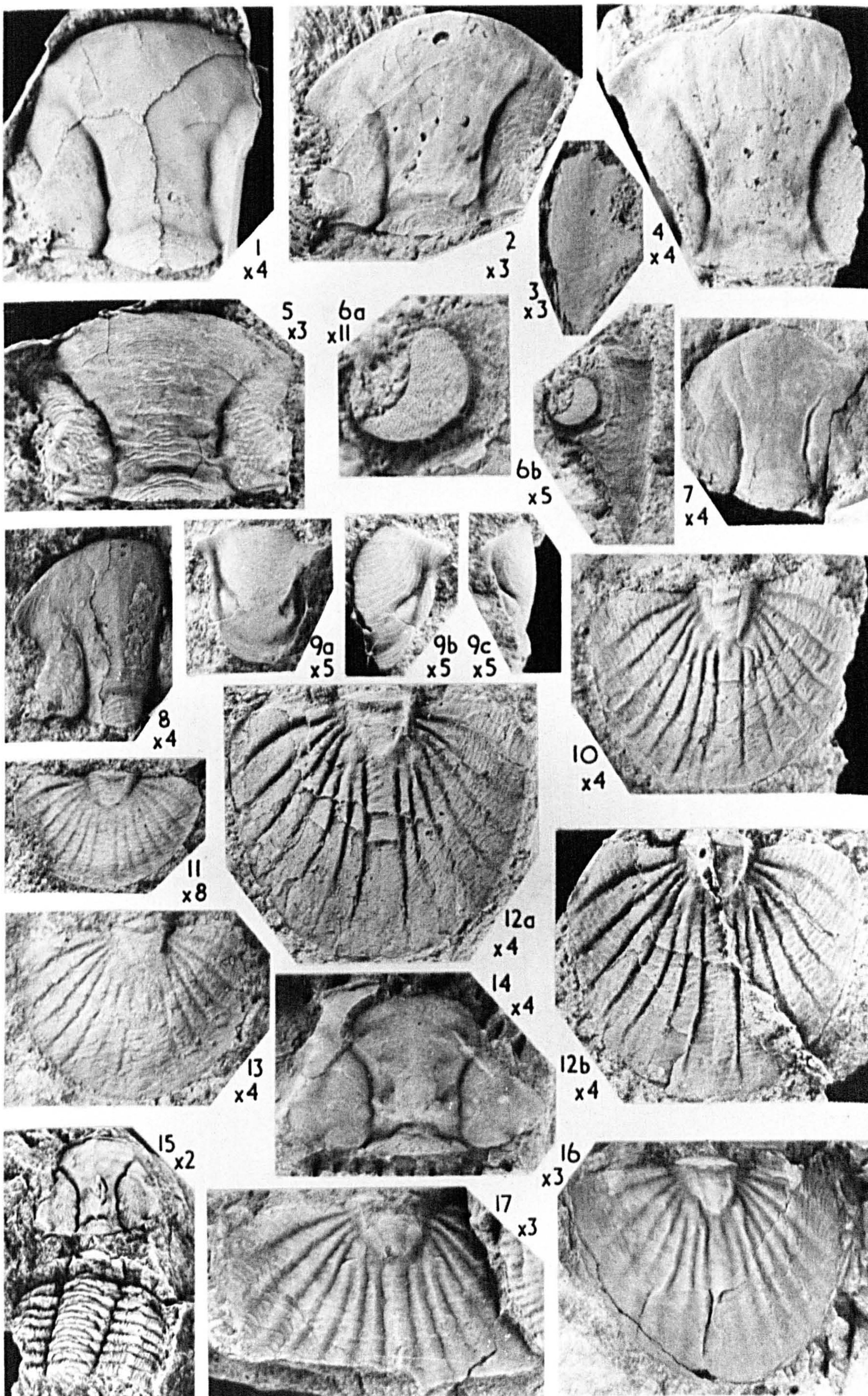
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PLATE 2

Fig. | Page

<u>Kosovopeltis</u> <u>andersoni</u> (Etheridge & Nicholson, 1879) 27

Wood Burn Formation, Locality 22 (Penkill)

1. Two cranidia, partly testate, dorsal view. SM A35164.
2. Pygidium, internal mould, dorsal view. Figured Reed 1906, pl. 12, fig.8. On same slab as Pl.1, fig.13. BM In22652a.
3. Cranidium, internal mould, dorsal view. Figured Reed 1906, pl. 12, fig.11. On same slab as Pl.1, fig.13. BM In22652d.
4. Cranidium, partly exfoliated, dorsal view. GSM 32980.
5. Latex rubber cast of external mould of pygidium, dorsal view. BM In22655.
6. Paralectotype pygidium, internal mould, dorsal view. Figured Nicholson & Etheridge 1879, pl.12, fig.4. BM In22651.
7. Latex rubber cast of external mould of pygidium, dorsal view. HM A67.

<u>Opsypharus</u> <u>maccallumi</u> (Salter, 1867) 32

Newlands Formation, Locality 14 (Newlands Farm).

8. Cranidium, internal mould, dorsal view. BM In43173.

9a,b. Cranidium, internal mould, 9a dorsal view, 9b oblique lateral view. HM A4790.

11. Cranidium, internal mould, dorsal view. BM In43183.

14a,b. Pygidium, dorsal view, 14a latex rubber cast, 14b internal mould with doublure revealed. BM In43191.

13. Free cheek, internal mould, dorsal view. HM A9056.

15. Latex rubber cast of external mould of cranidium, oblique lateral view. BM In43187.

Mulloch Hill Formation, Locality 8 (Rough Neuk)

10a,b. Pygidium, internal mould, 10a dorsal view, 10b lateral view. Figured Nicholson & Etheridge 1879, pl.12, fig.2. BM In21797.

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

12. Lectotype thorax and pygidium with disarticulated cranidium, internal mould, dorsal view. Figured Salter 1867, pl.30, fig.3. OUM C5.

PLATE 2

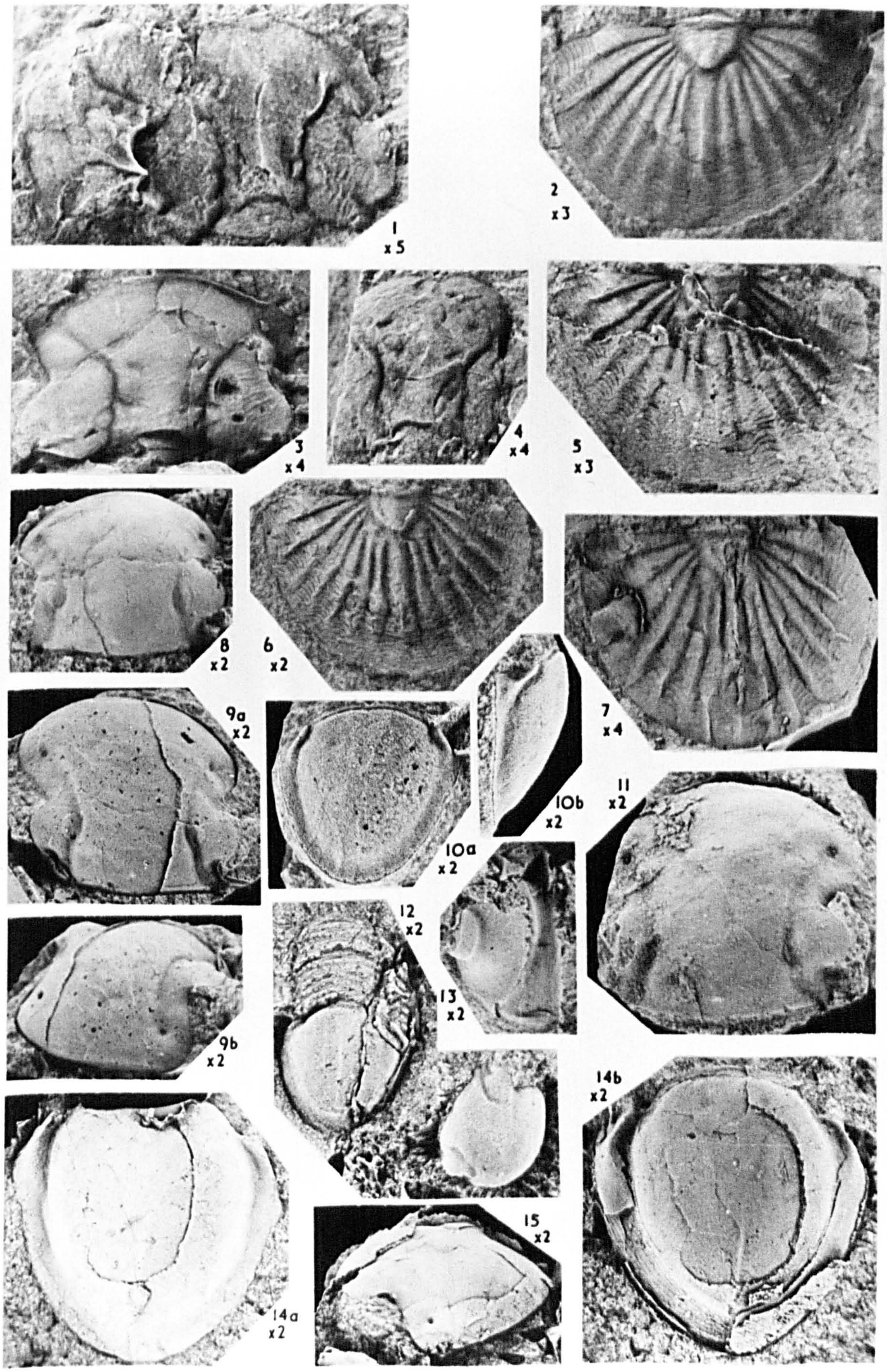
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PLATE 3 continued

Fig.		Page

	<u>Bumastus</u>? <u>vulsus</u> sp. nov.	17

Wood Burn Formation, Locality 22 (Penkill).

15a,b. Almost complete dorsal shield, partly exfoliated, 15a lateral view, 15b dorsal view. BM In21759.

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

16. Cranidium, internal mould, dorsal view. GSE M2676[b].

17. Pygidium, partly exfoliated, dorsal view. GSE M2587[a].

PLATE 3

Fig.		Page
Opsypharus maccallumi (Salter, 1867)	32

Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9)

1. Cranidium, internal mould, dorsal view. Figured Reed 1904, pl.9, fig.8. BM In21795.

6. Pygidium, internal mould, dorsal view. Figured Reed 1904, pl.9, fig.9. BM In21796a.

Newlands Formation, Locality 14 (Newlands Farm).

2. Cranidium, internal mould, dorsal view. BM In43174.

3a,b. Free cheek, dorsal view, 3a internal mould with doublure revealed, 3b latex cast of external mould. BM In43169.

5. Rostral plate and part of free cheek doublure, internal mould, ventral view. HM A4813.

8. Cranidium, internal mould, dorsal view. HM A4798.

9. Pygidium, internal mould with doublure revealed, dorsal view. HM A4819.

10. Latex rubber cast of external mould of anterior part of cranidium, anterior view. BM In43174.

11. Pygidium, internal mould, dorsal view. HM A4801.

14. Pygidium, internal mould, dorsal view. HM A4795.

Mulloch Hill Formation, Locality 8 (Rough Neuk).

4a,b. Complete dorsal shield, 4a latex rubber cast of external mould, dorsal view, 4b internal mould, lateral view. HM A9031.

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

7a,b. Paralectotype pygidium, internal mould with part of doublure revealed, 7a lateral view, 7b dorsal view. Figured Salter 1867, pl.30, fig.2. OUM C4.

13. Paralectotype pygidium, internal mould with part of doublure revealed, dorsal view. Figured Salter 1867, pl.28, fig.1. GSM 35906.

Mulloch Hill Formation, Locality 9.

12. Pygidium, internal mould with doublure revealed, dorsal view. BM In47723.

PLATE 3

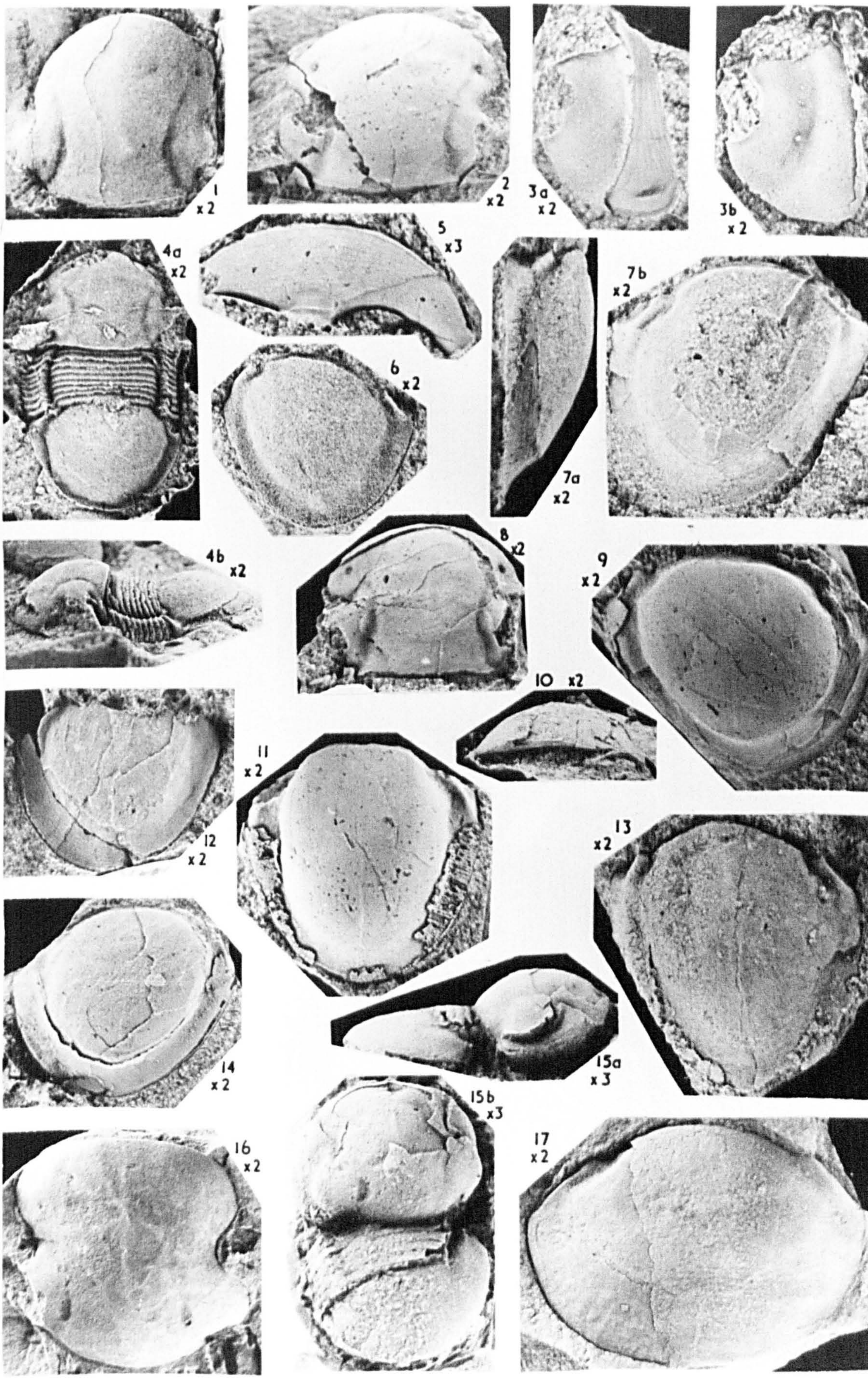
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PLATE 4 continued

Fig.		Page
	Stenopareia thomsoni (Salter, 1867)	36

Mulloch Hill Formation, Locality 8 (Rough Neuk).

13. 8 incomplete thoracic segments, internal mould, dorsal view. BM In21863.

PLATE 4

Fig.		Page

Fig.		Page
	<u>Bumastus</u>? <u>vulsus</u> sp. nov.	17

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

1. Cranidium, internal mould, dorsal view. Figured Reed 1904, pl.9, fig.1. BM In21754.
2. Holotype pygidium, internal mould with doublure revealed, dorsal view. Figured Reed 1904, pl.9, fig.2. BM In21755.
3. Cranidium, partly exfoliated, dorsal view. GSE M2682[a].
5. Free cheek, dorsal view. BM In21719.
6. Pygidium, partly exfoliated with doublure revealed, dorsal view. YH B153b.
7. Pygidium, internal mould with doublure revealed, dorsal view, GSE M3008[d].
10. Pygidium, partly exfoliated with part of doublure revealed, dorsal view. YH B154a.

Wood Burn Formation, Locality 22 (Penkill).

4a,b. Rostral plate, 4a ventral view, 4b dorsal view. Figured Nicholson & Etheridge 1879, pl.11, fig.13. BM In21710.

8. Free cheek, dorsal view. BM In21760.
9. Pygidium, internal mould with doublure revealed, dorsal view. GSM 4261.

<u>Stenopareia</u> <u>thomsoni</u> (Salter, 1867) 36

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

11. Paralectotype incomplete dorsal shield, internal mould, dorsal view. Figured Salter 1851, pl.9, fig.3; 1867, pl.28, fig.2. GSM 35907.

Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9).

12. Pygidium, internal mould, dorsal view. Figured Nicholson & Etheridge 1879, pl.11, fig.9. BM In21858.
13. Eight incomplete thoracic segments, dorsal view. BM In21863.
14. Paralectotype pygidium, internal mould, dorsal view. Figured Salter 1867, pl.28, fig.3. GSM 35908.
15. Paralectotype pygidium, internal mould, dorsal view. Figured Salter 1867, pl.30, fig.10. SM A34883.

PLATE 4

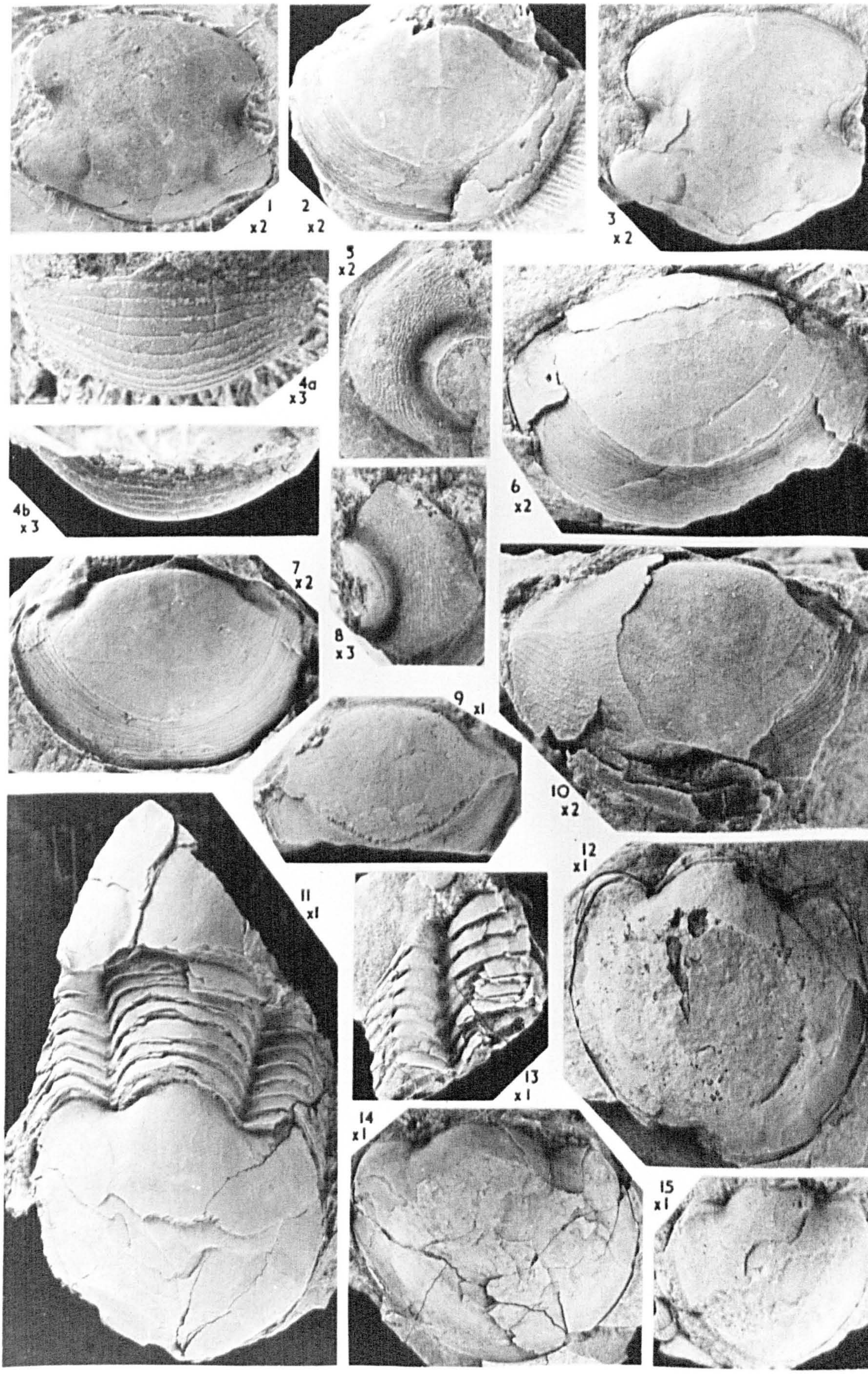
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PLATE 5

Fig.		Page

<u>Stenopareia</u> <u>thomsoni</u> (Salter, 1867) 36

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

1a,b. Lectotype, alomost complete dorsal shield, 1a internal mould, dorsal view, RSM 1967.58.46., 1b P.V.C. cast of external mould, dorsal view, OUM C3.

Mulloch Hill Formation, Locality 8 (Rough Neuk).

2. Pygidium, internal mould, dorsal view. SM A34882.
3. Free cheek, internal mould, dorsal view. Figured Reed 1904, pl.10, fig.7. BM In21861.
4. Free cheek with doublure, internal mould, oblique view. Figured Reed 1904, pl.10, fig.6. BM In21864.

Mulloch Hill Formation, Locality 6 (Craigens Quarry).

5a,b. Rostral plate, 5a latex rubber cast of external mould, dorsal view, 5b internal mould, dorsal view. Figured Reed 1904, pl.9, fig.13. BM In21822.

<u>Stenopareia</u> <u>acymata</u> sp. nov. 40

Woodland Formation, Locality 18 (Woodland Point).

6a,b. Holotype, almost complete dorsal shield, partly exfoliated, dorsal view. Figured Reed 1904, pl.8, fig.7. BM In21709.
7. Pygidium, partly exfoliated, dorsal view. Figured Reed 1904, pl.8, fig.6. BM In21706a.

PLATE 5

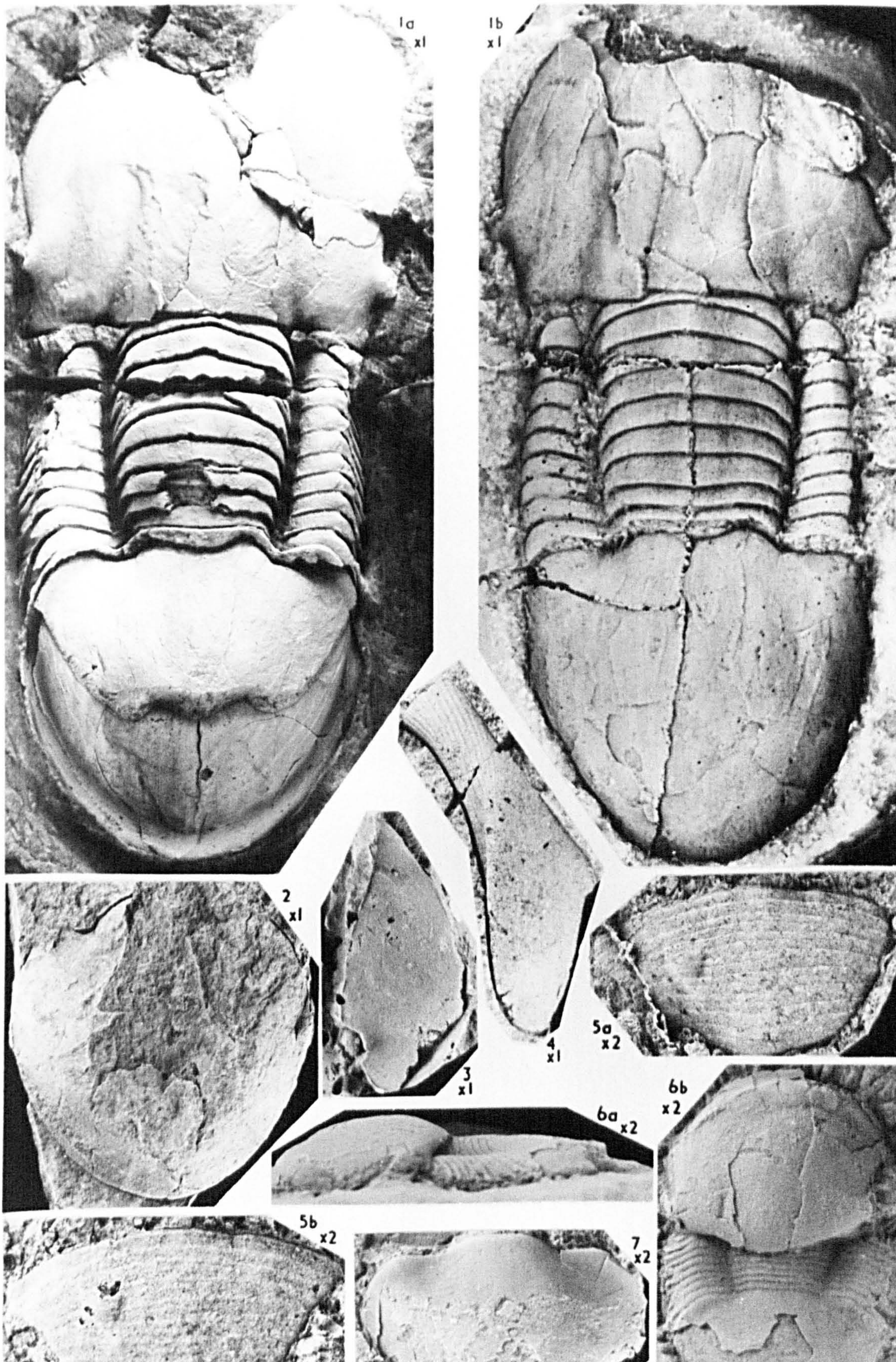


PLATE 6

Fig.		Page
	Stenopareia acymata sp. nov.	40

Woodland Formation, Locality 18 (Woodland Point).

1. Cranidium, partly exfoliated, dorsal view. Figured Reed 1904, pl.8, fig.8. BM In21707.
2. Pygidium, internal mould with small part of exoskeleton preserved and with doublure revealed, dorsal view. SM A35132.

3a,b. Pygidium, dorsal view, 3a internal mould with small part of exoskeleton preserved on the right anteriorly with doublure revealed, 3b latex rubber cast of external mould. HM A4739.

4. Free cheek, dorsal view. Figured Reed 1904, pl.8, fig.9. BM In21706c.
5. Doublured of free cheek, partly exfoliated, ventral view. BM In21876.

Stenopareia glochin sp. nov. 42.

Mulloch Hill Formation, Locality 8 (Rough Neuk).

6. Cranidium, internal mould, dorsal view. YH R7b.

Newlands Formation, Locality 14 (Newlands Farm).

7. Rostral plate, internal mould, ventral view. BM In43170.
9. Cranidium, internal mould, dorsal view. HM A4725.
10. Holotype pygidium, internal mould with doublure revealed, dorsal view. YH NW305.
11. Latex rubber cast of external mould of pygidium, dorsal view. BM In43167.
12. Latex rubber cast of external mould of pygidium, dorsal view. YH NW306.

Newlands Formation, Locality 11.

8. Cranidium, internal mould, dorsal view. HM C28.

PLATE 6

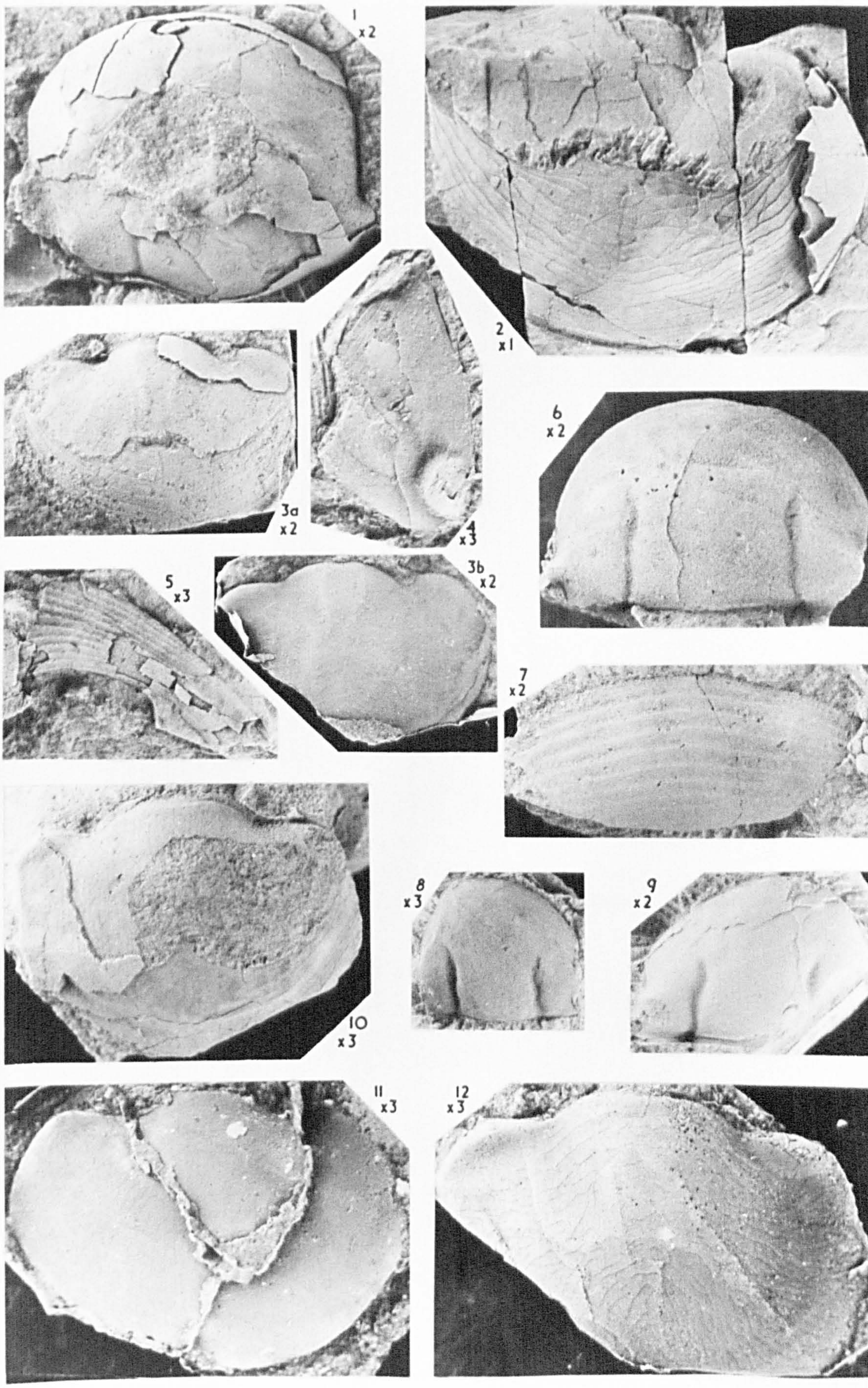


PLATE 7

Fig. Page

<u>Stenopareia</u> <u>catathema</u> sp. nov. 43.

Wood Burn Formation, Locality 22 (Penkill).

1a,b. Cranidium, partly exfoliated, 1a dorsal view, 1b dorsal posterior view. GSM 32976.

2a-c. Cranidium, 2a internal mould, dorsal posterior view, 2b internal mould, dorsal view, 2c latex rubber cast of external mould, dorsal posterior view. Figured Nicholson & Etheridge 1879, pl. 12, fig.13. BM In21713.

3. Rostral plate, partly exfoliated, ventral view. BM In46638.

4. Cranidium, internal mould, dorsal view (with background blacked out). Figured Nicholson & Etheridge 1879, pl.12, fig.1. BM In21868.

5a,b. Rostral plate, partly exfoliated, 5a ventral view, 5b dorsal view. Figured Nicholson & Etheridge 1879, pl.11, fig.12. BM In21870.

7. Thorax and pygidium, partly exfoliated, dorsal view. Figured Nicholson & Etheridge 1879, pl.12, fig.12. BM In21714.

9. One thoracic segment and pygidium, dorsal view. BM In46628.

10. Pygidium, internal mould with some exoskeleton remaining, with doublure revealed, dorsal view. Figured Reed 1935, pl.2, fig.9. HM A936.

11. Holotype pygidium, partly exfoliated with part of doublure revealed, dorsal view. Figured Nicholson & Etheridge 1879, pl. 11, fig.10, Reed 1904, pl.8, fig.10. BM In21712.

12. Pygidium, internal mould with doublure revealed, dorsal view. Figured Reed 1904, pl.8, fig.5. BM In21702.

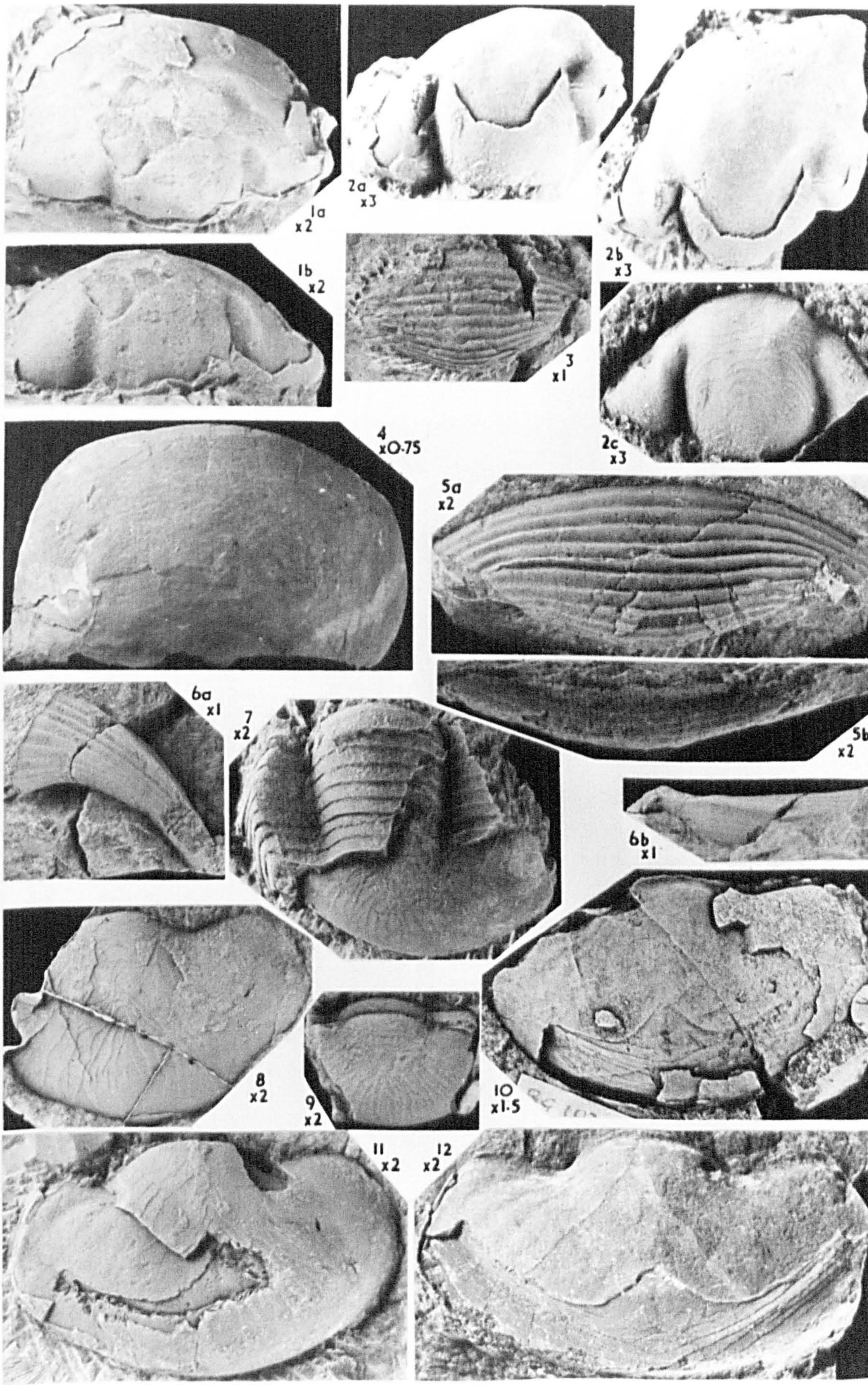
Lower Camregan Grits, Locality 19 (Camregan Wood).

6a,b. Doublure of free cheek, internal mould, 6a dorsal view, 6b anterior lateral view. BM In21865.

?Lauchlan Formation, Locality 23 (Penwhapple Glen).

8. Latex rubber cast of external mould of pygidium, dorsal view. GSM 70729.

PLATE 7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x1·5
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x2
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x2

PLATE 8 continued

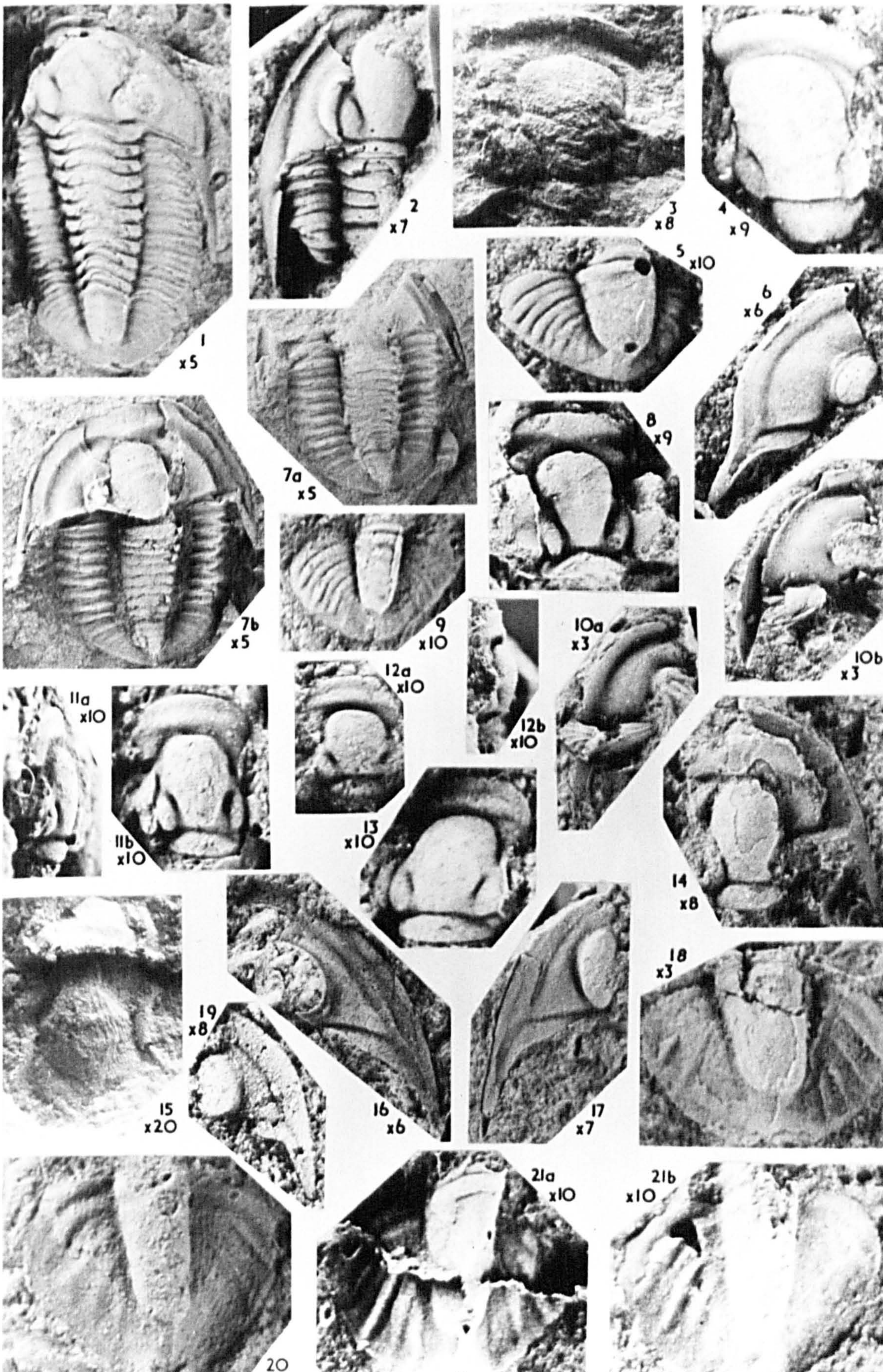
Fig.		Page

Fig.		Page
	<u>Decoroproetus</u> <u>farragatus</u> sp. nov.	52
	Newlands Formation, Locality 14 (Newlands Farm).	
15.	Latex rubber cast of external mould of hypostome, ventral view, 'S.E.M.' photograph. SM A74611.	
16.	Latex rubber cast of external mould of free cheek, dorsal view. YH NW447.	
17.	Free cheek, internal mould, dorsal view. YH NW446.	
18.	Pygidium, internal mould, dorsal view. BM In42702.	
20.	Pygidium, internal mould, dorsal view. BM In42697.	
21a,b.	Pygidium, dorsal view, 21a latex rubber cast of external mould, 21b internal mould. BM In42701.	
	<u>Decoroproetus</u> sp.	54
	Lower Camregan Grits, Locality 16 (Craigfin).	
19.	Latex rubber cast of external mould of free cheek, dorsal view. LRMC 12.	

PLATE 8

Fig.		Page
	Cyphoproetus externus (Reed, 1935)	48
	Newlands Formation, Locality 14 (Newlands Farm).	
1.	Almost complete specimen, internal mould, dorsal view. Figured Reed 1904, pl.11 fig.11, Owens 1973, pl.6, fig.8. BM In21955.	
2.	Latex rubber cast of external mould of part of cephalon and six thoracic segments, dorsal view. BM In21953.	
4.	Latex rubber cast of external mould of cranidium, dorsal view. YH NW431.	
5.	Latex rubber cast of external mould of pygidium, dorsal view. BM In43730.	
6.	Latex rubber cast of external mould of free cheek, dorsal view. YH NW445.	
	Mulloch Hill Formation, Locality 10 (Gully).	
3.	Latex rubber cast of external mould of cranidium, dorsal view, 'S.E.M.' photograph. YH G12/2.	
9.	Pygidium, internal mould, dorsal view. LRMC 20.	
	Cyphoproetus pugionis sp. nov.	49
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
7a,b.	Holotype complete specimen, dorsal view, 7a internal mould (cephalon damaged), 7b latex rubber cast of external mould. Figured Nicholson & Etheridge 1879, pl.14, fig.15. GSE 5775.	
8.	Cranidium, internal mould, dorsal view. YH B156.	
10a,b.	Free cheek, dorsal view, 10a latex rubber cast of external mould, 10b internal mould. YH B146.	
14.	Cranidium with part of free cheek, partly testate, dorsal view. GSE M2633[a].	
	Decoroproetus farragatus sp. nov.	52
	Newlands Formation, Locality 14 (Newlands Farm).	
11a,b.	Cranidium, internal mould, 10a lateral view, 10b dorsal view. YH NW432.	
12a,b.	Cranidium, internal mould, 12a dorsal view, 12b lateral view. YH NW427.	
13.	Holotype, latex rubber cast of external mould, dorsal view. SM A74613b.	

PLATE 8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21b x10

PLATE 9 continued

Fig.		Page
	<u>Harpidella</u> <u>newlandensis</u> (Begg, 1950)	62

Newlands Formation, Locality 14 (Newlands Farm).

14a,b. Holotype cranidium, internal mould, 14a lateral view, 14b dorsal view. Figured Begg 1950, pl.14, fig.7. HM A3824.

15. Cranidium, internal mould, dorsal view. SM A4873.

16a,b. Cranidium, internal mould, 16a dorsal view, 16b lateral view. BM In43154.

17. Cranidium, internal mould, dorsal view. YH NW425.

18a,b. Cranidium, internal mould, 18a lateral view, 18b dorsal view. YH N618a.

PLATE 9

Fig. Page

Astroproetus scoticus (Reed, 1941) 55

Mulloch Hill Formation, Locality 5.

1a,b. 1a damaged cephalon and thorax, internal mould, dorsal view, 1b latex rubber cast of external mould, ventral view. YH K5/8b.

Astroproetus pseudolatifrons (Reed, 1904) 56

Lower Camregan Grits, Locality 19 (Camregan Wood).

2. Cranidium, internal mould, dorsal view. GSE JS17939.

3. Pygidium, internal mould, dorsal view. GSE JS17942.

4. Free cheek, internal mould, dorsal view. GSE JS17935.

Proetid gen. indet. 57

Newlands Formation, Locality 14 (Newlands Farm).

5a,b. Pygidium, dorsal view, 5a internal mould, 5b latex rubber cast of external mould. BM In42687.

Warburgella (Warburgella) capetos sp. nov. 58

Knockgardner Formation, Locality 24. (Knockgardner Quarry)

6. Free cheek, internal mould, dorsal view. YH 3K24a.

7. Holotype cranidium, internal mould, dorsal view. GSE M1020[e].

8. Latex rubber cast of external mould of free cheek, dorsal view. YH 1K20a.

9. Cranidium, internal mould, dorsal view. GSE M1036[e].

10. Pygidium, internal mould, dorsal view. RCK 5.

11. Latex rubber cast of external mould of pygidium, dorsal view. YH 2K22.

?Warburgella (Warburgella) sp. 60

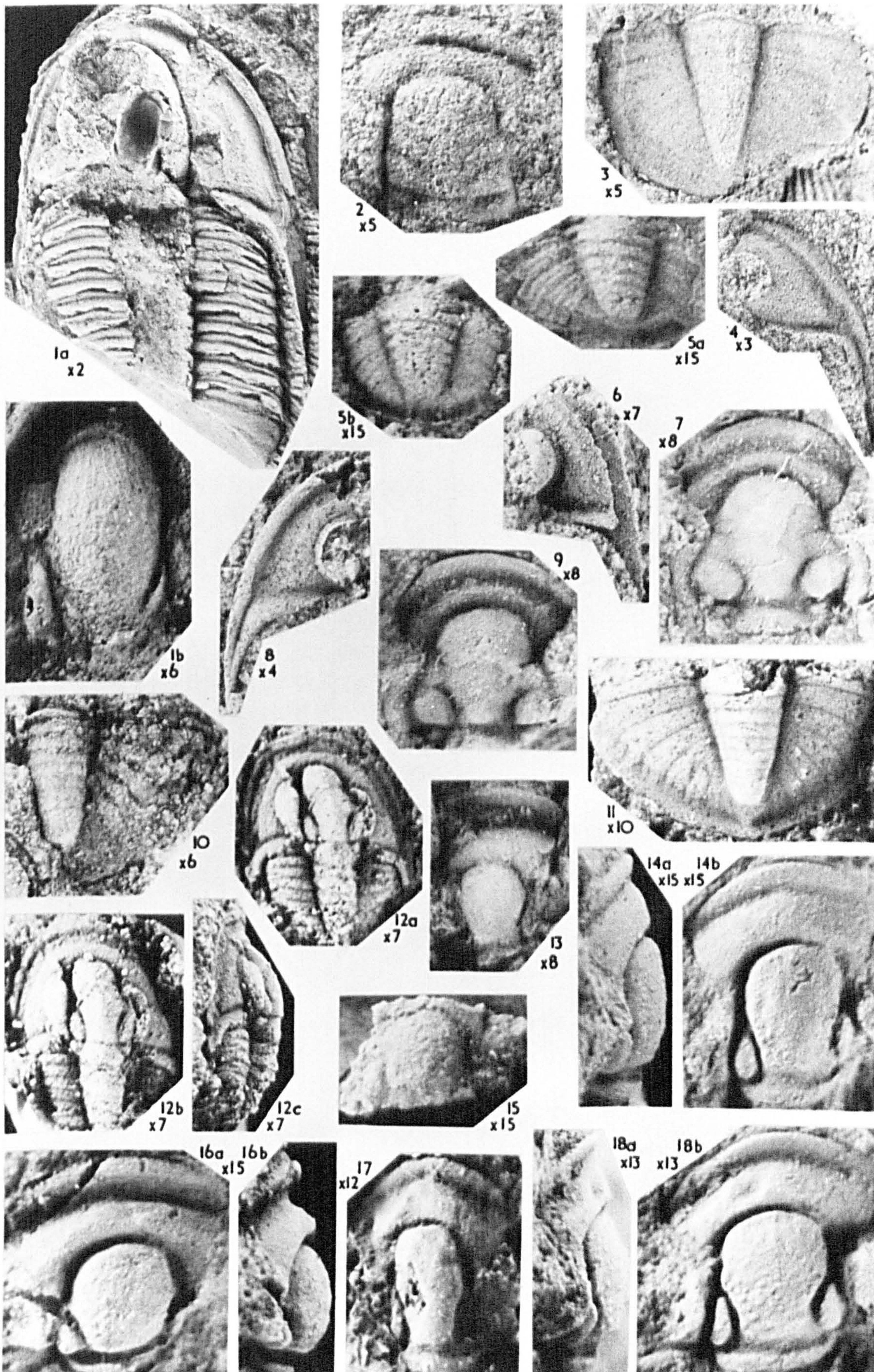
Lower Camregan Grits, Locality 16 (Craigfin).

12a-c. Cephalon and part of thorax, 12a internal mould, dorsal view, 12b latex rubber cast of external mould, dorsal view, 12c internal mould, lateral view. LRMC 11.

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

13. Latex rubber cast of external mould of cranidium, dorsal view. YH B142.

PLATE 9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12c x7
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18b x13

Fig.		Page
	<u>Hadromeros elongatus</u> (Reed, 1931a)	69
	Woodland Formation, Locality 18 (Woodland Point).	
10.	Hypostome, partly testate, ventral view. BM In44517a.	
14.	Latex rubber cast of external mould of pygidium, dorsal view. BM In22818.	
15.	Cranidium, partly testate, dorsal view. BM In44467a.	
	<u>Proromma</u> sp.	70
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
13.	Cranidium, internal mould, dorsal view. GSE M3006[a].	
17.	Latex rubber cast of external mould of cephalon and thorax, dorsal view. GSE M3001[a].	

PLATE 10

Fig.		Page
	<u>Harpidella</u> cf. <u>H.</u> <u>newlandensis</u> (Begg, 1950)	65
	Lower Camregan Grits, Locality 16 (Craigfin).	
1.	Latex rubber cast of external mould of cranidium, dorsal view. GSE EG8226.	
2.	Cranidium, internal mould, dorsal view. HM A9117/2.	
3a,b.	Cranidium, internal mould, 3a lateral view, 3b dorsal view. HM A9152/1a.	
5.	Latex rubber cast of external mould of cranidium, dorsal view. HM A9150.	
	Lower Camregan Grits, Locality 19 (Camregan Wood).	
4a-c.	Complete specimen, internal mould, 4a dorsal view, 4b lateral view, 4c anterior view. BM In21954.	
	<u>Scotoharpes</u> <u>volsellatus</u> sp. nov.	66
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
6a-c.	Almost complete enrolled specimen, 6a latex rubber cast of external mould, dorsal view, 6b internal mould, oblique posterior view, 6c internal mould, dorsal view. YH B55.	
7.	Holotype, latex rubber cast of external mould of incomplete cephalon, dorsal view. Figured Reed 1903, pl.2, fig.14, Whittington 1950, pl.7, fig.13. BM In20759.	
	<u>Hadromeros</u> <u>elongatus</u> (Reed, 1931a)	69
	Newlands Formation, Locality 14 (Newlands Farm).	
8.	Latex rubber cast of external mould of hypostome, ventral view. YH NW449a.	
9.	Latex rubber cast of external mould of free cheek, dorsal view. YH N659b.	
11.	Latex rubber cast of external mould of cranidium, dorsal view. YH NW103b.	
16.	Latex rubber cast of external mould of cranidium, dorsal view. YH NW104.	
	Mulloch Hill Formation, Locality 10 (Gully).	
12.	Cranidium, internal mould, dorsal view. YH G42b.	

PLATE 10

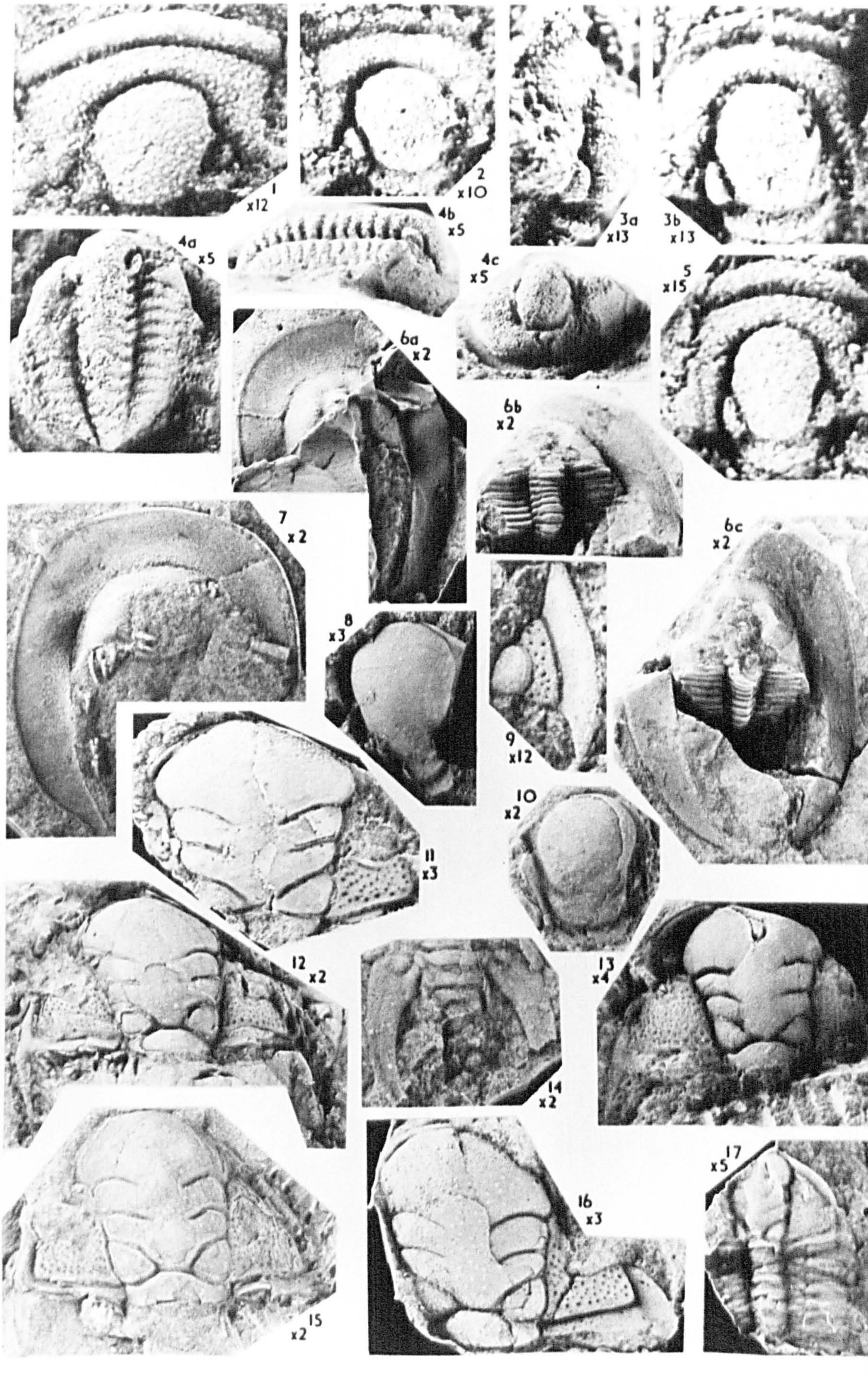
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PLATE 11 continued

Fig. Page

<u>Youngia</u> aff. <u>Y.</u> <u>trispinosa</u> (Young, 1868) 75

Newlands Formation, Locality 14 (Newlands Farm).

11a,b. Cranidium, internal mould, 11a dorsal view, 11b lateral view. HM A2992.

<u>Encrinurus</u> <u>mullochensis</u> Reed 1931 77

Wood Burn Formation, Locality 22 (Penkill).

12. Complete specimen, internal mould, dorsal view. HM A796.

PLATE 11

Fig.	Page

	<u>Proromma</u> sp.	70
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
1.	Cranidium, internal mould, dorsal view. GSE M2679[a].	
2.	5 thoracic segments, partly exfoliated, dorsal view. BM In23421.	
	<u>Deiphon</u> sp.	72
	Woodland Formation, Locality 18 (Woodland Point).	
3a-c.	Cranidium, partly exfoliated, 3a dorsal view, 3b posterior view, 3c anterior view. BM In44468.	
	Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9).	
4a-c.	Cranidium, internal mould, 4a lateral view, 4b posterior view, 4c dorsal view. BM In23518.	
	Mulloch Hill Formation, Locality 10 (Gully).	
5.	Latex rubber cast of external mould of cranidium, dorsal view. YH G57.	
	Newlands Formation, Locality 14 (Newlands Farm).	
6.	Cranidium, internal mould, dorsal view, 'S.E.M.' photograph. YH NW315.	
7a,b.	Hypostome, internal mould, 7a ventral view, 7b lateral view. BM In42704.	
8a,b.	Hypostome, dorsal view, 8a latex rubber cast of external mould, 8b internal mould. YH NW584.	
	<u>Youngia</u> <u>trispinosa</u> (Young, 1868)	74
	Wood Burn Formation, Locality 20.	
9a,b.	Cranidium, dorsal view, 9a latex rubber cast of external mould, 9b internal mould. YH PW29.	
	Wood Burn Formation, Locality 22 (Penkill).	
10.	Free cheek, partly exfoliated, dorsal view. Figured Nicholson & Etheridge 1878, pl.7, fig.12. BM In23493.	

PLATE II

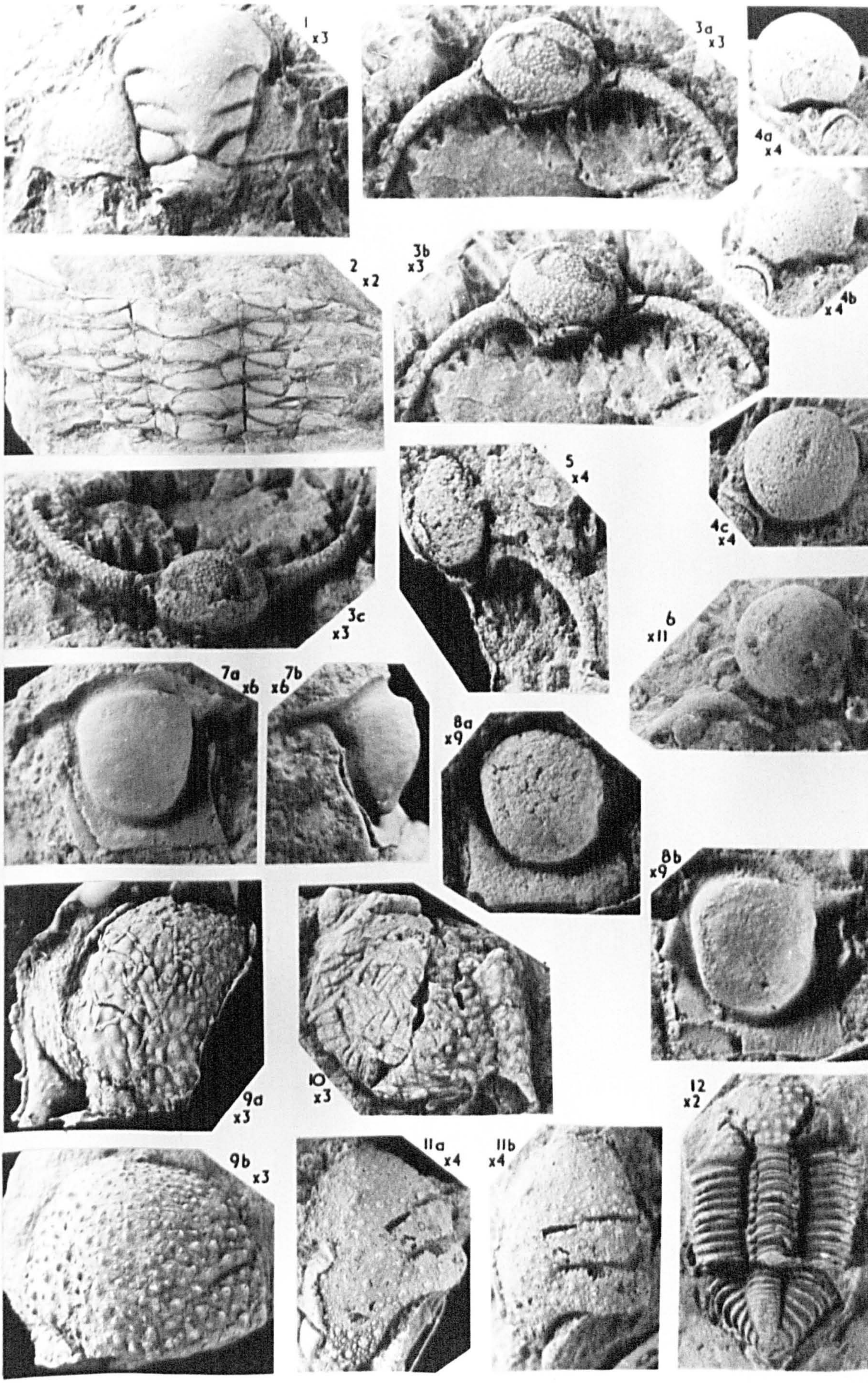

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PLATE 12

Fig. Page

Encrinurus mullochensis Reed, 1931 77

Wood Burn Formation, Locality 22 (Penkill).

1a-d. Lectotype complete specimen, internal mould, 1a complete dorsal view, 1b cranidium, dorsal view, 1c pygidium, dorsal view, 1d lateral view. Figured Nicholson & Etheridge 1878, pl.8, fig.2. BM In23210.

2a-d. Paralectotype complete specimen, partly exfoliated, 2a cephalon, lateral view, 2b pygidium, dorsal view, 2c dorsal view, 2d cephalon,dorsal view. Figured Nicholson & Etheridge 1878, pl.8, fig.1. BM In23205.

3a-c. Complete specimen, partly exfoliated, 3a anterior view, 3b lateral view, 3c dorsal view. GSM 32933.

10a,b. Cranidium, internal mould, 10a oblique lateral view, 10b dorsal view. BM In46586.

13. Cranidium, internal mould, dorsal view. BM In46585.

14. Free cheek, partly exfoliated, dorsal view. Figured Reed 1906, pl.19, fig.11. BM In23501.

16. Pygidium, internal mould, dorsal view. GSM 4212.

18. Latex rubber cast of external mould of pygidium, dorsal view. BM In46605.

19a,b. Paralectotype pygidium, 19a lateral view. 19b dorsal view. Figured Nicholson & Etheridge 1878, pl.8, fig.3. BM In23206.

20. Pygidium, internal mould, dorsal view. BM In46602.

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

4. Free cheek, internal mould, dorsal view. YH B30.

5. Cranidium, internal mould, dorsal view. BM In23154.

6a,b. Latex rubber cast of external mould of cephalon, thorax and hypostome, 6a hypostome, ventral view, 6b cephalon and thorax, dorsal view. BM In23204.

7. Free cheek, internal mould, dorsal view. YH B61.

8. Free cheek, internal mould, dorsal view. YH B94b.

9. Hypostome, internal mould, ventral view. YH B58.

11. Cranidium, internal mould, dorsal view. YH B101.

12. Latex rubber cast of external mould of free cheek, dorsal view. YH B21b.

15a,b. Pygidium, internal mould, 15a dorsal view, 15b lateral view. YH B105

17. Latex rubber cast of external mould of pygidium, dorsal view. YH B20.

PLATE 12

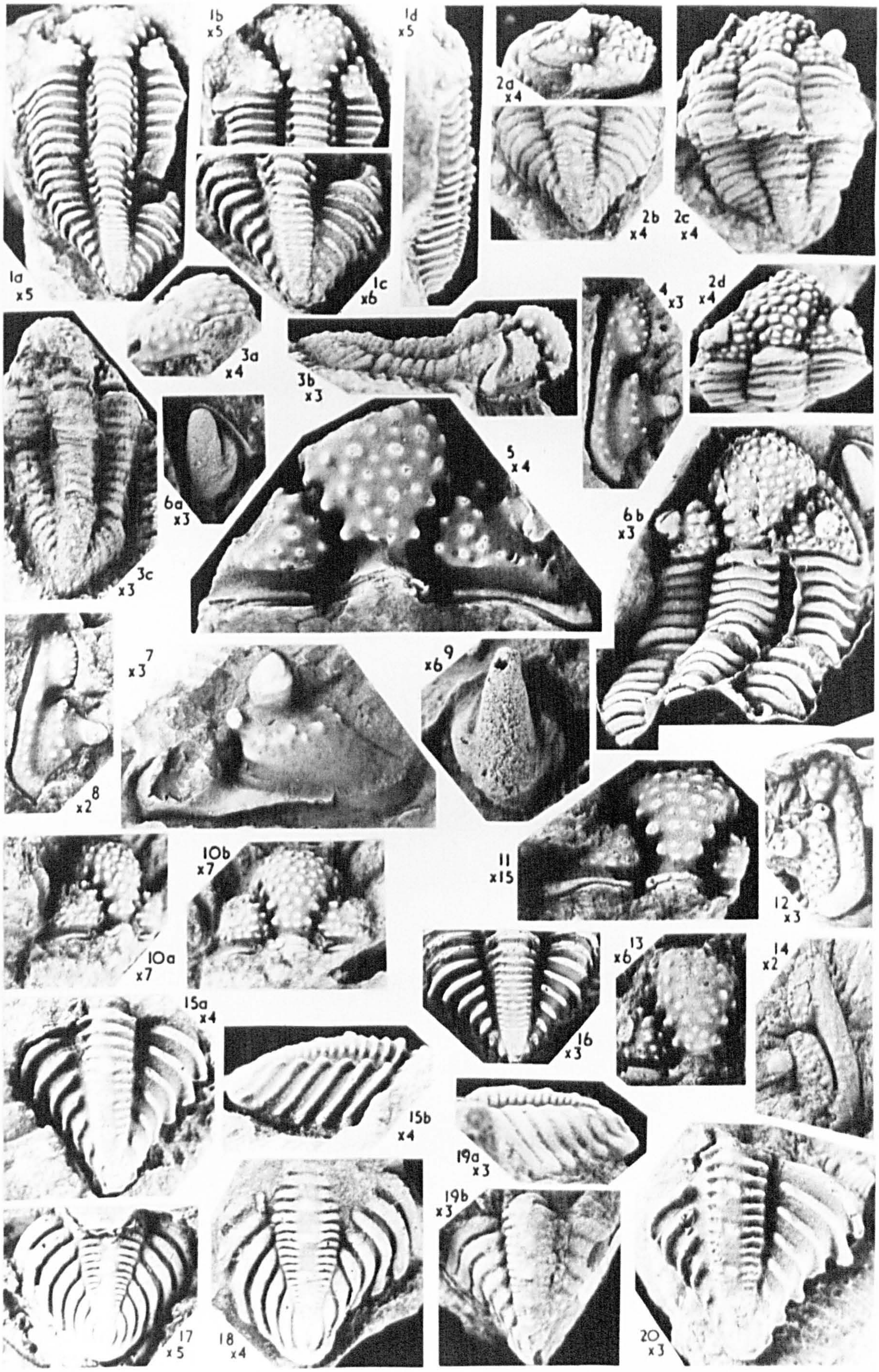
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Fig.		Page
	Encrinurus squarrosus sp. nov.	83
	Woodland Formation, Locality 18 (Woodland Point).	
10.	Cranidium, dorsal view. YH WB12.	
16.	Free cheek, dorsal view. YH W8.	
18.	Pygidium, dorsal view. SM A35126.	

Fig.		Page
	<u>Encrinurus</u> <u>squarrosus</u> sp. nov.	83

Newlands Formation, Locality 14 (Newlands Farm).

1a-c. Holotype, latex rubber cast of external mould of complete specimen, 1a dorsal view, 1b lateral view, 1c anterior view. HM A5368.

2a,b. Cranidium, internal mould, 2a dorsal view, 2b lateral view. BM In43121.

3. Latex rubber cast of external mould of free cheek, dorsal view. YH NW74/25.

7. Latex rubber cast of external mould of cranidium, dorsal view. HM A1010a.

8. Hypostome, internal mould, ventral view. HM A799/3.

11. Latex rubber cast of external mould of hypostome, ventral view. BM It9098.

12. Hypostome, internal mould, ventral view. BU 10.

13. Small cranidium with genal spine, internal mould, dorsal view. HM A10298.

14a,b. Pygidium, internal mould, 14a dorsal view, 14b lateral view. YH NW74/20.

17. Latex rubber cast of external mould of pygidium, dorsal view. BM In43109.

19. Pygidium, internal mould, oblique lateral view, showing irregular rib formation. HM A5696.

20. Latex rubber cast of external mould of pygidium, oblique lateral view showing irregular rib formation. YH NW74/23.

21. Latex rubber cast of external mould of pygidium, dorsal view. HM A548.

Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9).

4. Latex rubber cast of external mould of cranidium, dorsal view. BM In23175.

5. Cranidium, internal mould, dorsal view on the same block as Fig.4.

6. Almost complete specimen, partly exfoliated, dorsal view. BM In23172.

9a,b. Free cheek, dorsal view, 9a internal mould, 9b latex rubber cast of external mould. BM In47744.

15. Pygidium, internal mould, dorsal view. BM In23220.

PLATE 13

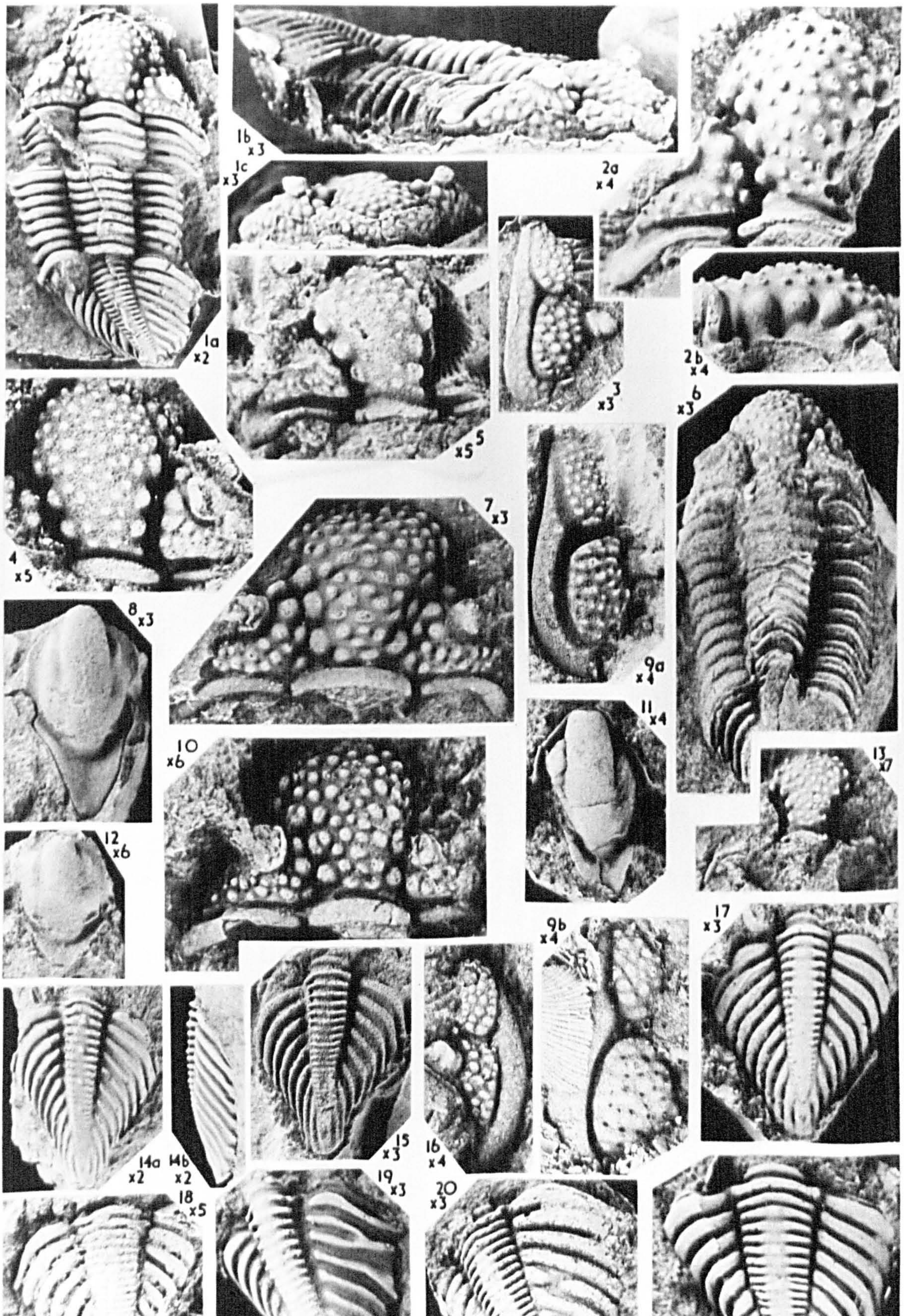
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Fig.		Page
	<u>Encrinurus</u> cf. <u>E.</u> <u>squarrosus</u> sp. nov.	96
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
17.	Latex rubber cast of external mould of free cheek, dorsal view. YH B68.	
18.	Latex rubber cast of external mould of pygidium, dorsal view. YH B27a.	
19.	Pygidium, internal mould, dorsal view. BM In23153.	
16.	Pygidium, internal mould, dorsal view. Probably from base of Wood Burn Formation in ?Penwhapple Glen. ?Figured Salter 1851, pl.9, fig.4. BM I5336.	
	<u>Encrinurus</u> sp. A	96
	Knockgardner Formation, Locality 24 (Knockgardner Quarry).	
20.	Latex rubber cast of external mould of cranidium, dorsal view. YH 1K3a.	
21.	Pygidium, internal mould, dorsal view. YH 3K27a.	
22a,b.	Hypostome, ventral view, 22a internal mould, 22b latex rubber cast of external mould. YH 3K4.	
23.	Latex rubber cast of external mould of free cheek, dorsal view. YH K500.	
24.	Free cheek, internal mould, dorsal view. GSE M1036[e].	
25.	Pygidium, internal mould, dorsal view. YH 3K22a.	
26.	Latex rubber cast of external mould of pygidium, dorsal view. YH 3K28b.	

PLATE 14.

Fig.		Page
	Encrinurus stateratus sp. nov.	92

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

1. Cranidium, internal mould, dorsal view. HM A10281a.

5a,b. Pygidium, internal mould, 5a dorsal view, 5b lateral view. GSE M2632[a].

Wood Burn Formation, Locality 22 (Penkill).

2a,b. Cranidium, dorsal view, 2a latex rubber cast of external mould, 2b internal mould. BM In46619.

3. Holotype cranidium, internal mould, dorsal view. BM In23209.

4. Pygidium, internal mould, dorsal view. Figured Nicholson & Etheridge 1879, pl.10, fig.7. BM In23207.

6a,b. Pygidium, partly exfoliated, 6a dorsal view, 6b lateral view. BM In46599.

7. Pygidium, partly exfoliated, dorsal view. HM A50/1.

Encrinurus confusevarus sp. nov. — 94

Lower Camregan Grits, Locality 19 (Camregan Wood).

8. Holotype cranidium, internal mould, dorsal view. BM In23189.

9. Latex rubber cast of external mould of free cheek, dorsal view. YH C102.

10. Pygidium, internal mould, dorsal view. BM In23188.

12. Latex rubber cast of external mould of cranidium, dorsal view. YH C71.

13. Latex rubber cast of external mould of pygidium, dorsal view. BM In23190.

15. Latex rubber cast of external mould of pygidium, dorsal view. YH C90.

Lower Camregan Grits, Locality 16 (Craigfin).

11. Latex rubber cast of external mould of free cheek, dorsal view. HM A9118/b.

14. Latex rubber cast of external mould of hypostome, ventral view. HM A9116.

PLATE 14

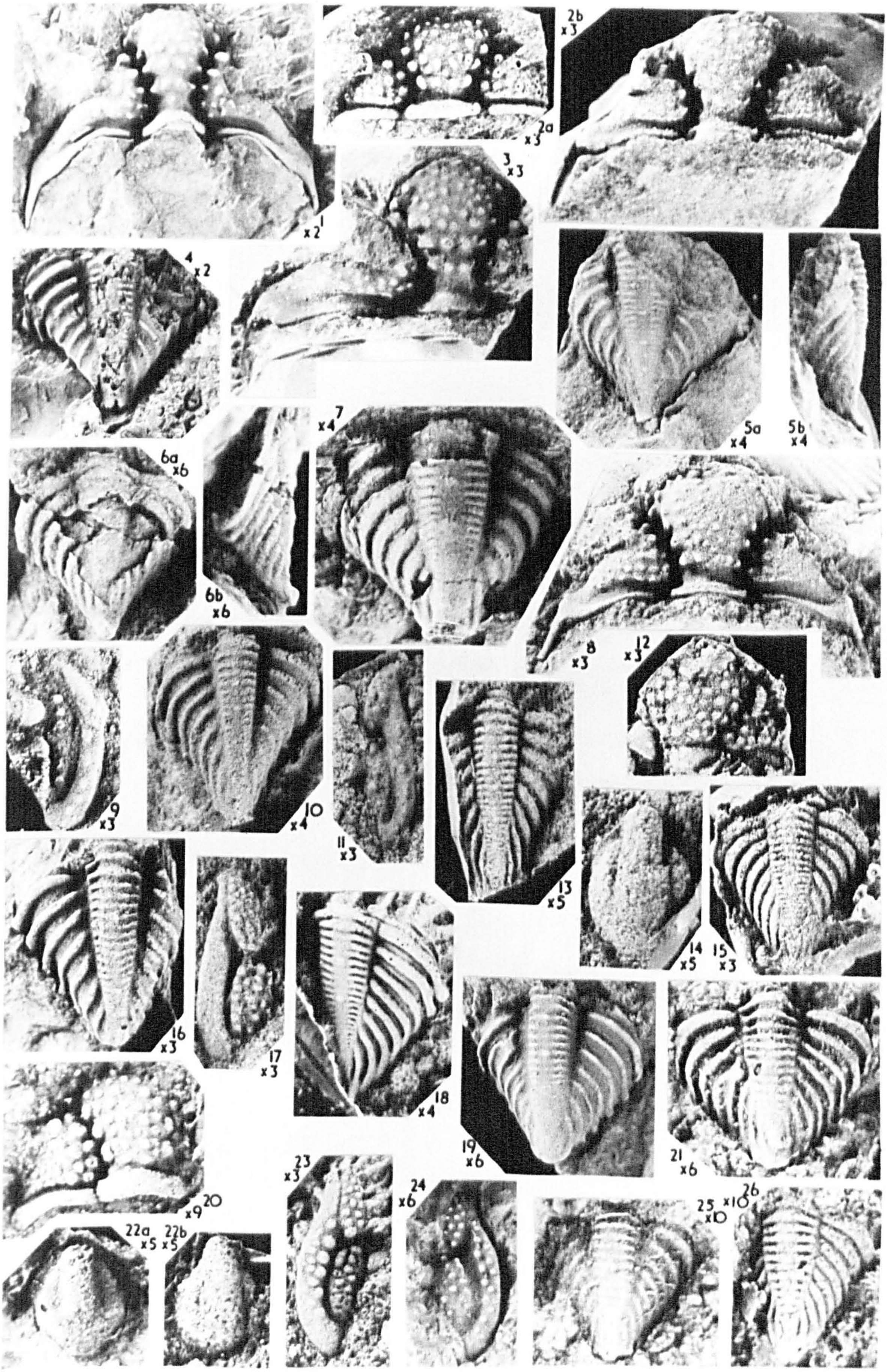
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Fig.		Page

Fig.		Page
	Calymene subdiademata subdiademata McCoy, 1851	102
	Mulloch Hill Formation, Mulloch Hill (Localities 1-7).	
20.	Lectotype cranidium, internal mould, dorsal view. Figured Siveter 1973, pl.1, fig.9. SM A34872.	
	Woodland Formation, Locality 18 (Woodland Point).	
16.	Cranidium, dorsal view. YH WR166.	
	Calymene ?frontosa Lindström, 1885	109
	Wood Burn Formation, Locality 21 (Bargany Pond Burn).	
19.	Latex rubber cast of external mould of cranidium, dorsal view. LRMC 8.	
	Calymenid gen. et sp. indet.	110
	Knockgardner Formation, Locality 24 (Knockgardner Quarry).	
21.	Latex rubber cast of external mould of free cheek, dorsal view. YH 2K2a.	
22a,b.	Cranidium, internal mould, 22a lateral view, 22b dorsal view. RCK 8.	

PLATE 15

Fig.		Page

Encrinurus? muldooni sp. nov. 99

Newlands Formation, Locality 14 (Newlands Farm).

1a,b. Holotype cranidium, internal mould, 1a dorsal view, 1b anterior view. RSM 1889.91.17.

2a-c. Cranidium, internal mould, 2a anterior view, 2b dorsal view, 2c lateral view. YH NW120a.

3a-c. Cranidium, internal mould, 3a oblique lateral view, 3b dorsal view, 3c oblique anterior view. YH NW171.

4a,b. Free cheek, dorsal view, 4a latex rubber cast of external mould, 4b internal mould. HM A7395.

5. Latex rubber cast of external mould of cranidium, dorsal view. BM In43114.

6a,b. Pygidium, internal mould, 6a dorsal view, 6b lateral view. BM In43143.

7. Pygidium, internal mould, dorsal view. SM A35141.

9. Free cheek, internal mould, dorsal view. BM In43122.

Calymene subdiademata subdiademata McCoy 1851. 102

Newlands Formation, Locality 14 (Newlands Farm).

8. Cranidium, internal mould, dorsal view. Figured Reed 1906, pl.17, fig.13, refigured Siveter 1973, pl.1, fig.11. BM In23337.

10. Latex rubber cast of external mould of cranidium, dorsal view. YH N618.

11. Latex rubber cast of external mould of free cheek, dorsal view. YH NW444.

12. 2 cranidia lying at right angles to each other, internal mould, dorsal view. BM In43673.

13. Latex rubber cast of external mould of cranidium, dorsal view. YH NW57.

Mulloch Hill Formation, Mulloch Hill (Locality 8 or 9).

14a,b. Cranidium, internal mould, 14a lateral view, 14b dorsal view. Figured Reed 1906, pl.17, fig.12. BM In23331.

15. Latex rubber cast of external mould of cranidium, dorsal view. YH R80.

17. Almost complete specimen, internal mould, dorsal view. Figured Nicholson & Etheridge 1879, pl.10, fig.6. BM In23330.

18. Cranidium, internal mould, dorsal view. SM A34873.

PLATE 15

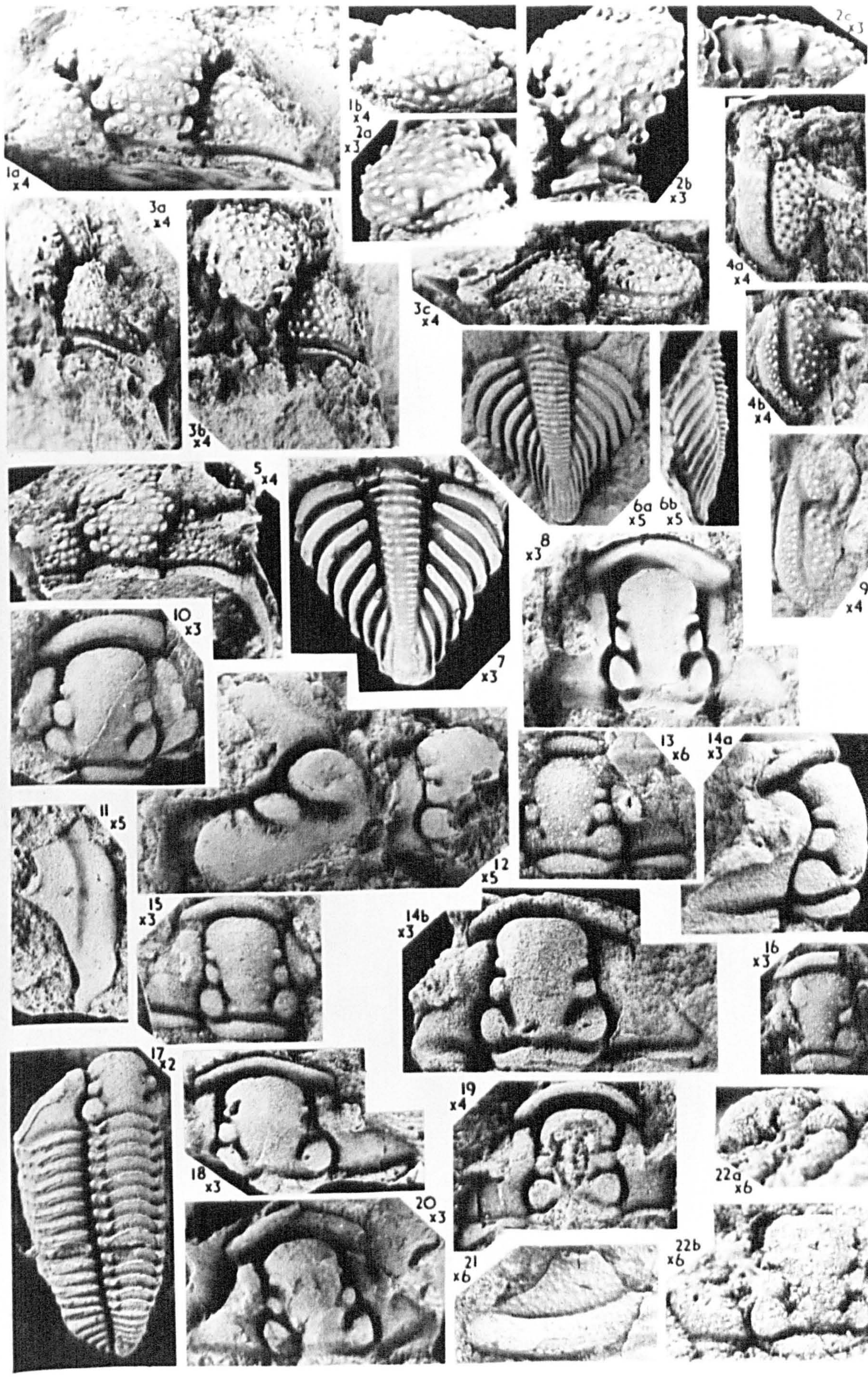

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Fig.		Page
	Acernaspis superciliexcelsis sp. nov.	111
	Newlands Formation, Locality 14 (Newlands Farm).	
22.	Pygidium, internal mould, dorsal view. BM In43248.	
23.	Pygidium, partly exfoliated, dorsal view. BM In43276.	
	Newlands Formation, Locality 11.	
13.	Immature cranidium showing genal spine, internal mould, dorsal view. HM A10308.	
18.	Latex rubber cast of external mould of hypostome, ventral view. Figured Begg 1943, pl.2, fig.9. HM A742.	

PLATE 16

Fig.		Page
	<u>Acernaspis</u> <u>superciliexcelsis</u> sp. nov.	111

Newlands Formation, Locality 14 (Newlands Farm).

1. Holotype, latex rubber cast of external mould of complete dorsal shield, dorsal view. BM In23571.

2. Latex rubber cast of external mould of cranidium, dorsal view. YH NW272.

3a,b. Cranidium, internal mould, 3a dorsal view, 3b lateral view. YH NW235.

4. Hypostome, internal mould, ventral view. YH NW455.

5. Cranidium, internal mould, lateral view to show position of visual surface. HM A1004/3.

6a,b. Complete dorsal shield, dorsal view, 6a internal mould, 6b latex rubber cast of external mould. Figured Reed 1906, pl.19, fig.23. BM In23574.

7a,b. Cranidium, internal mould, 7a dorsal view, 7b lateral view. Figured Reed 1906, pl.19, fig.22. BM In23573.

8. Visual surface, internal mould, lateral view. BU 11.

9. Latex rubber cast of external mould of cephalic doublure, ventral view. BM In43234.

10. Latex rubber cast of external mould of cephalic doublure, ventral view. HM A4408.

11. Free cheek with doublure revealed, internal mould, lateral view. YH NW263.

12. Latex rubber cast of external mould of cephalic doublure, ventral view. BM It9121.

14a,b. Complete specimen, dorsal view, 14a latex rubber cast of external mould, 14b internal mould. BM In23578.

15. Latex rubber cast of external mould of hypostome, ventral view. (Internal mould figured Begg 1950, pl.1, fig.11). HM A4145.

16. Latex rubber cast of external mould of half of cephalon, lateral view. BM In43264.

17. Latex rubber cast of external mould of dorsal shield, dorsal view. HM A4430.

19. Latex rubber cast of external mould of pygidium, dorsal view. BM In43232.

20. Free cheek, internal mould, dorsal view. Figured Reed 1906, pl.19, fig.21. BM In23572.

21. Latex rubber cast of external mould of pygidium showing irregularity, dorsal view. HM A5954.

PLATE 16

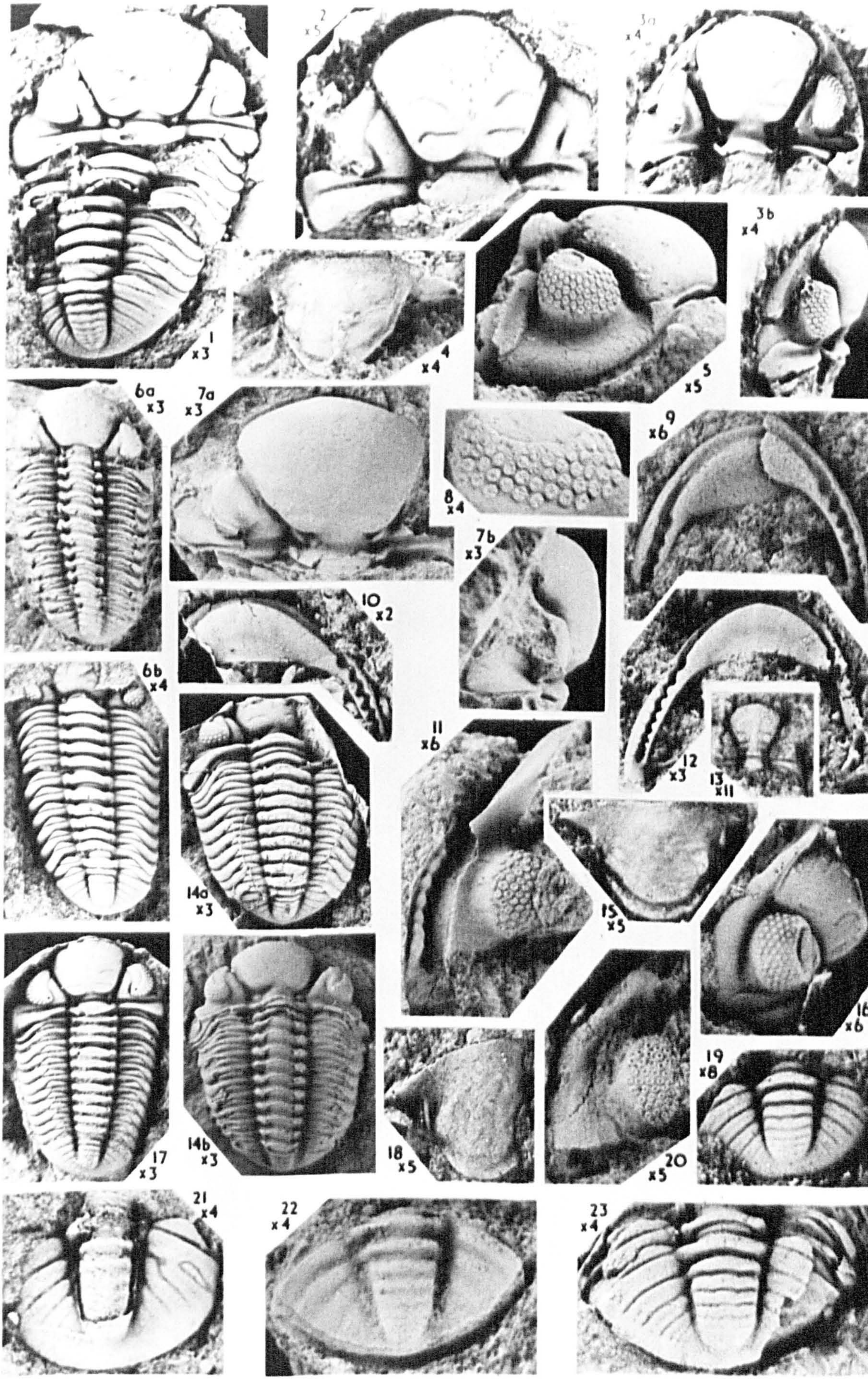
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PLATE 17 continued

Fig.		Page
	Acernaspis sp. A	123

Lower Camregan Grits, Locality 19 (Camregan Wood).

18. Cranidium, internal mould, dorsal view. YH C19.

19. Cephalic doublure, internal mould, ventral view. YH C17.

22. Cephalic doublure, internal mould, ventral view. YH C33.

Lower Camregan Grits, Locality 17 (Craigfin).

20. Latex rubber cast of external mould of pygidium, dorsal view. LRMC 14.

21. Latex rubber cast of external mould of cranidium, dorsal view. LRMC 1.

Wood Burn Formation, Locality 22 (Penkill).

23. Pygidium, partly exfoliated, dorsal view. BM In23587.

PLATE 17

Fig.		Page
	Acernaspis superciliexcelsis sp. nov.	111

Woodland Formation, Locality 18 (Woodland Point).

1. Incomplete dorsal shield, partly exfoliated, dorsal view. BM In23579.
2. Cranidium, dorsal view. BM In44457.
5. Pygidium, partly exfoliated, dorsal view. BM In23581.

Acernaspis xynon sp. nov. — 120

Woodland Formation, Locality 18 (Woodland Point).

3. Cranidium, dorsal view. BM In44479.
4. Pygidium, dorsal view. BM In47901.

6a,b. Holotype cranidium, 6a dorsal view, 6b oblique lateral view. BM In44521.

7. Pygidium, dorsal view. Figured Reed 1906, pl.19, fig.20. BM In23584.
10. Incomplete cephalic doublure, ventral view. YH W14.

Acernaspis cf. A. elliptifrons (Esmark, 1833) — 121

Mulloch Hill Formation, Locality 8 (Rough Neuk).

8. Latex rubber cast of external mould of cranidium, dorsal view. HM A5172.
11. Latex rubber cast of external mould of cephalic doublure, ventral view. YH R130.
13. Cranidium with separate pygidium glued on to same block, internal mould, dorsal view. Possibly figured Salter 1851, pl.9, figs2a,b. GSM 19232.
14. Latex rubber cast of external mould of free cheek, lateral view. YH R131.

15a,b. Cephalon and thorax, dorsal view, 15a latex rubber cast of external mould, 15b internal mould. YH R31.

16. Complete specimen, internal mould, dorsal view. BM In47922.
17. Pygidium, internal mould, dorsal view. YH R40.

Mulloch Hill Formation, Locality 6 (Craigens Quarry).

9. Complete specimen, internal mould, dorsal view. BM In23570.
12. Thorax and pygidium, internal mould, dorsal view. Figured Nicholson & Etheridge 1878, pl.7, fig.2. BM In23568.

PLATE 17

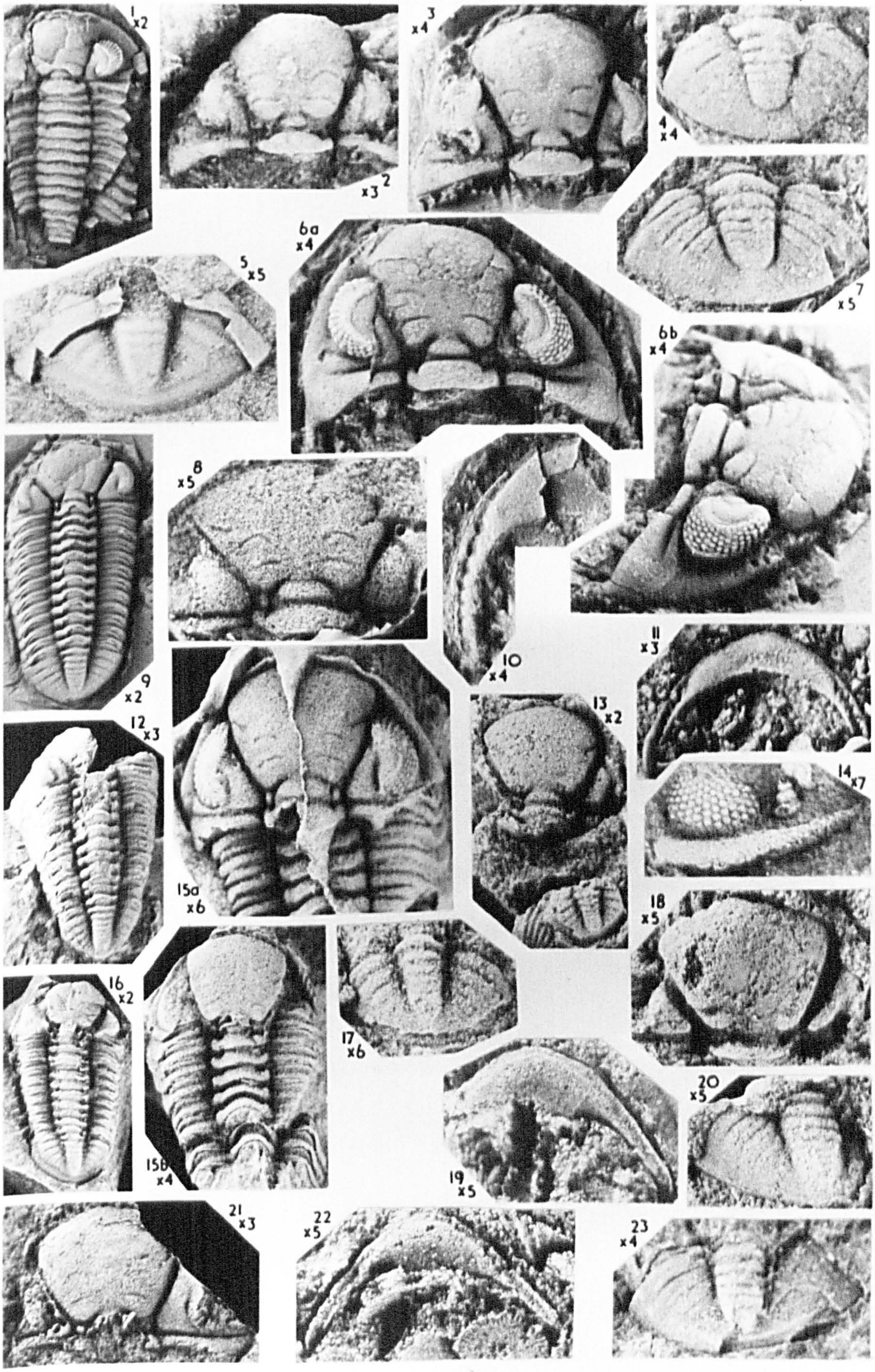
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PLATE 18 continued

Fig. Page

<u>Podowrinella</u> sp. 127

Lower Camregan Grits, Locality 19 (Camregan Wood).

14a-d. Cranidium; latex rubber cast of external mould, 14a anterior ventral view, 14b anterior view; internal mould, 14c ventral view. YH C107.

Lower Camregan Grits, Locality 17 (Craigfin).

15. Cranidium, internal mould, dorsal view. LRMC 2.

PLATE 18

Fig. | Page

Acernaspis sp. A. — 123

Wood Burn Formation, Locality 22 (Penkill).

1. Cranidium, almost completely exfoliated, dorsal view. BM In46622.
2. Thorax and pygidium, partly exfoliated, dorsal view. GSM 4274.

Lower Camregan Grits, Locality 19 (Camregan Wood).

5. Cranidium, internal mould, dorsal view. YH C98.

Acernaspis woodburnensis Clarkson et al., 1977 — 124

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

3. Part of free cheek showing visual surface, internal mould, lateral view. YH B27.

4a,b. Syntype complete specimen, partly exfoliated, 4a dorsal view, 4b lateral view. Figured Clarkson et al., pl.19, figs.12,13. GSE 5780.

6. Latex rubber cast of external mould of pygidium, dorsal view. GSE JS17995.

7. Holotype complete specimen, internal mould, dorsal view. Figured Clarkson et al., 1977, pl.19, fig.11. GSE 5777.

8a,b. Cranidium, internal mould, 8a dorsal view, 8b lateral view. Figured Reed 1906, pl.19, fig. 19. BM In23565.

Podowrinella straitonensis Clarkson et al. 1977 — 126

Knockgardner Formation, Locality 24 (Knockgardner Quarry).

9a,b. Free cheek and cephalic doublure, internal mould, 9a cephalic doublure, ventral view, 9b visual surface, lateral view. RCK 2.

10. Latex rubber cast of external mould of cranidium, dorsal view. RCK 19.

11. Cranidium, internal mould, dorsal view. RCK 12.

12a,b. Pygidium, dorsal view, 12a internal mould, 12b latex rubber cast of ecternal mould. YH 3K3.

13. Latex rubber cast of external mould of pygidium, dorsal view. YH 1K26.

PLATE 18

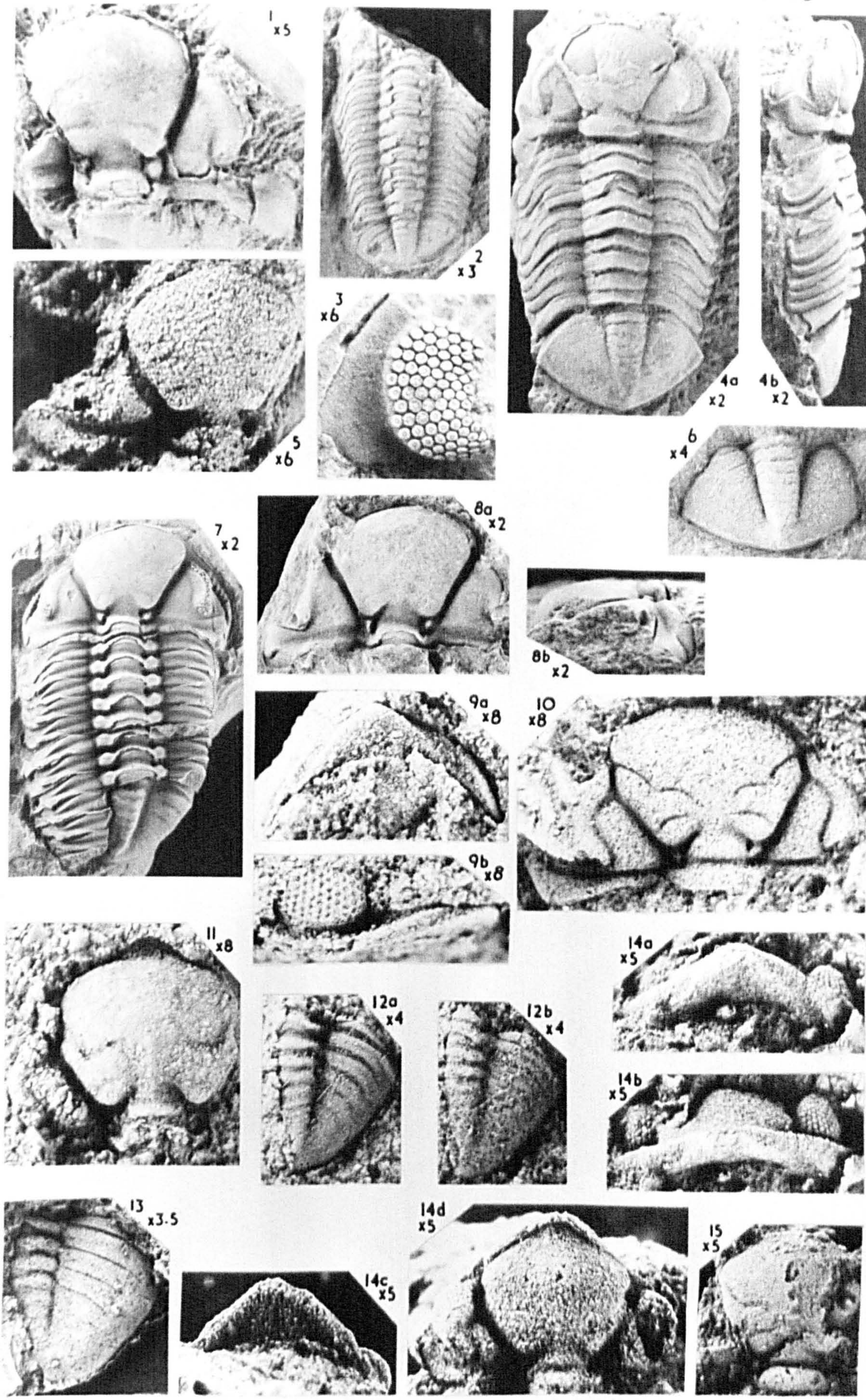
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PLATE 19 continued

Fig. Page

<u>Platylichas</u> <u>scoticus</u> (Reed, 1906) 136

Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

13a,b. Paralectotype cranidium, internal mould, 13a, anterior view, 13b lateral view, 13c dorsal view. Figured Reed 1906, pl.14, figs.5,5a. BM In22725.

Mulloch Hill Formation, Locality 7.

14. Latex rubber cast of external mould of cranidium, dorsal view. HM A10312.

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

15. Paralectotype, latex rubber cast of external mould of pygidium, dorsal view. Figured Nicholson & Etheridge 1878, pl.9, fig.8; Reed 1906, pl.14, fig.8. GSM 16192.

PLATE 19

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	Lichas silvestris Reed, 1925	129

Woodland Formation, Locality 18 (Woodland Point).

1a,b. Cranidium, dorsal view, 1a partly exfoliated, 1b latex rubber cast of external mould. Figured Reed 1906, pl.14, fig.15; Phleger 1936, text-fig.15; Tripp 1957, text-fig.5G. BM In22797.

2. Cranidium, partly exfoliated, dorsal view. BM In44514.

3. Hypostome, slightly exfoliated, ventral view. Figured Reed 1906, pl.14, fig.16; Tripp 1957, text-fig.4F. BM In22798.

Mulloch Hill Formation, Locality 10 (Gully).

4. Latex rubber cast of external mould of cranidium, dorsal view. YH G54.

5. Pygidium, internal mould, dorsal view. HM A9108.

6. Axis ring and left pleura of thoracic segment, internal mould, dorsal view. YH G11.

Mulloch Hill Formation, Locality 9 (Mulloch Hill, in wood).

7a-c. Holotype pygidium, 7a internal mould, lateral view, 7b latex rubber cast of external mould, dorsal view, 7c internal mould, dorsal view. Figured Reed 1925, pl.2, fig.1. BM In36954.

Dicranopeltis sp. 134

Newlands Formation, Locality 14 (Newlands Farm).

8. Latex rubber cast of external mould of cranidium, dorsal view. BM In43155.

10, Small cranidium, internal mould, dorsal view. YH NW95.

Woodland Formation, Locality 18 (Woodland Point).

9. Cranidium, internal mould, dorsal view. BM In22792.

Mulloch Hill Formation, Locality 11.

11. Small cranidium, internal mould, dorsal view. HM A8948.

Platylichas scoticus (Reed, 1906) 136

Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

12a-c. Lectotype cranidium, internal mould, 12a lateral view, 12b dorsal view, 12c anterior view. Figured Nicholson & Etheridge 1878, pl.9, figs.11,12; Reed 1906, pl.14, figs.6,6a. BM In22726.

PLATE 19

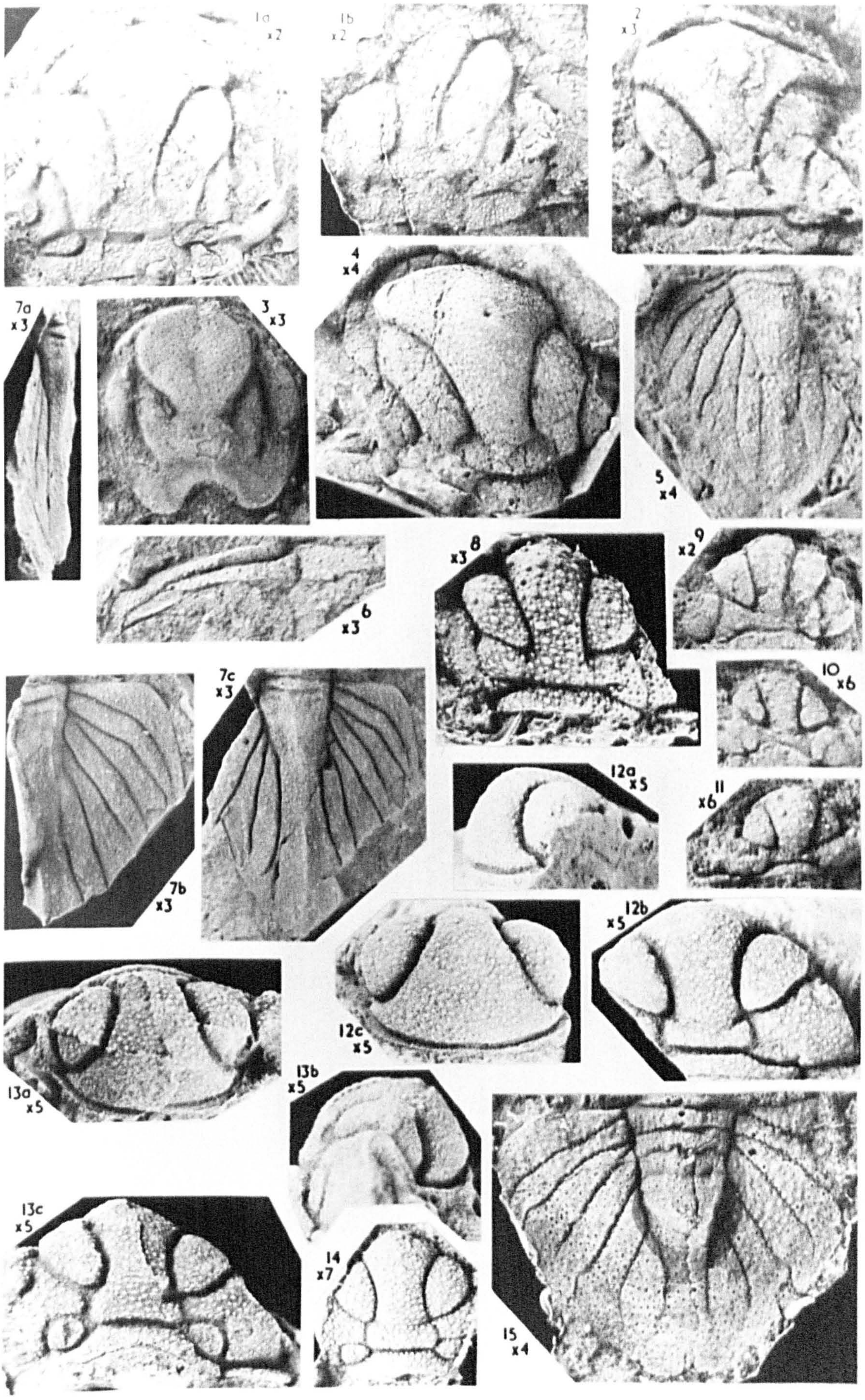

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PLATE 20 continued

Fig. Page

<u>Hemiarges serus</u> (Reed, 1935) 140

Newlands Formation, Locality 14 (Newlands Farm).

11. Cranidium, internal mould, dorsal view. Figured Reed 1906, pl.14, fig.3. BM In22718.

13a,b. Pygidium, dorsal view, 13a internal mould, 13b latex rubber cast of external mould. Figured Reed 1906, pl.14, fig.4; Tripp 1958, pl.85, fig.20. BM In22724.

Mulloch Hill Formation, Locality 3.

14. Latex rubber cast of external mould of pygidium, dorsal view. YH K3/18.

<u>Hemiarges rolfei</u> Lamont, 1965 143

Knockgardner Formation, Locality 24.

15a,b. Cranidium, dorsal view, 15a latex rubber cast of external mould, 15b internal mould. YH 3K65.

16. Hypostome, internal mould, ventral view. YH 3K140.

17. Incomplete pygidium, internal mould, dorsal view. GSE M1010[e].

18. Hypostome, internal mould, ventral view. YH 1K27.

PLATE 20

Fig. | | Page

Platylichas scoticus (Reed, 1906) 136

Mulloch Hill Formation, Locality 8 (Rough Neuk).

1a-c. Paralectotype cranidium, internal mould, 1a anterodorsal view, 1b dorsal view, 1c lateral view. Figured Reed 1906, pl.20, fig.12. BM In22738.

3. Paralectotype hypostome, internal mould, ventral view. Figured Reed 1906, pl.14, fig.7. BM In22727.

Mulloch Hill Formation, Locality 6 (Craigens Quarry).

2. Cranidium, internal mould, dorsal view. SM A34884.

5. Paralectotype pygidium, internal mould, dorsal view. Figured Reed 1906, pl.14, fig.9. BM In22732.

Mulloch Hill Formation, Mulloch Hill (Localities 1-7).

4. Paralectotype cranidium, internal mould, dorsal view. Figured Reed 1906, pl.14, fig.14. BM In22794.

6. Latex rubber cast of external mould of pygidium, dorsal view. BM In42681.

Woodland Formation, Locality 18 (Woodland Point).

8. Latex rubber cast of external mould of hypostome, ventral view. BM In22735.

Platylichas cf. P. scoticus (Reed, 1906) 139

Lower Camregan Grits, Locality 19 (Camregan Wood).

9a-c. Incomplete cranidium, internal mould, 9a anterior view, 9b lateral view, 9c dorsal view. Figured Reed 1906, pl.14, fig.10. BM In22734.

Hemiarges serus (Reed, 1935). 140

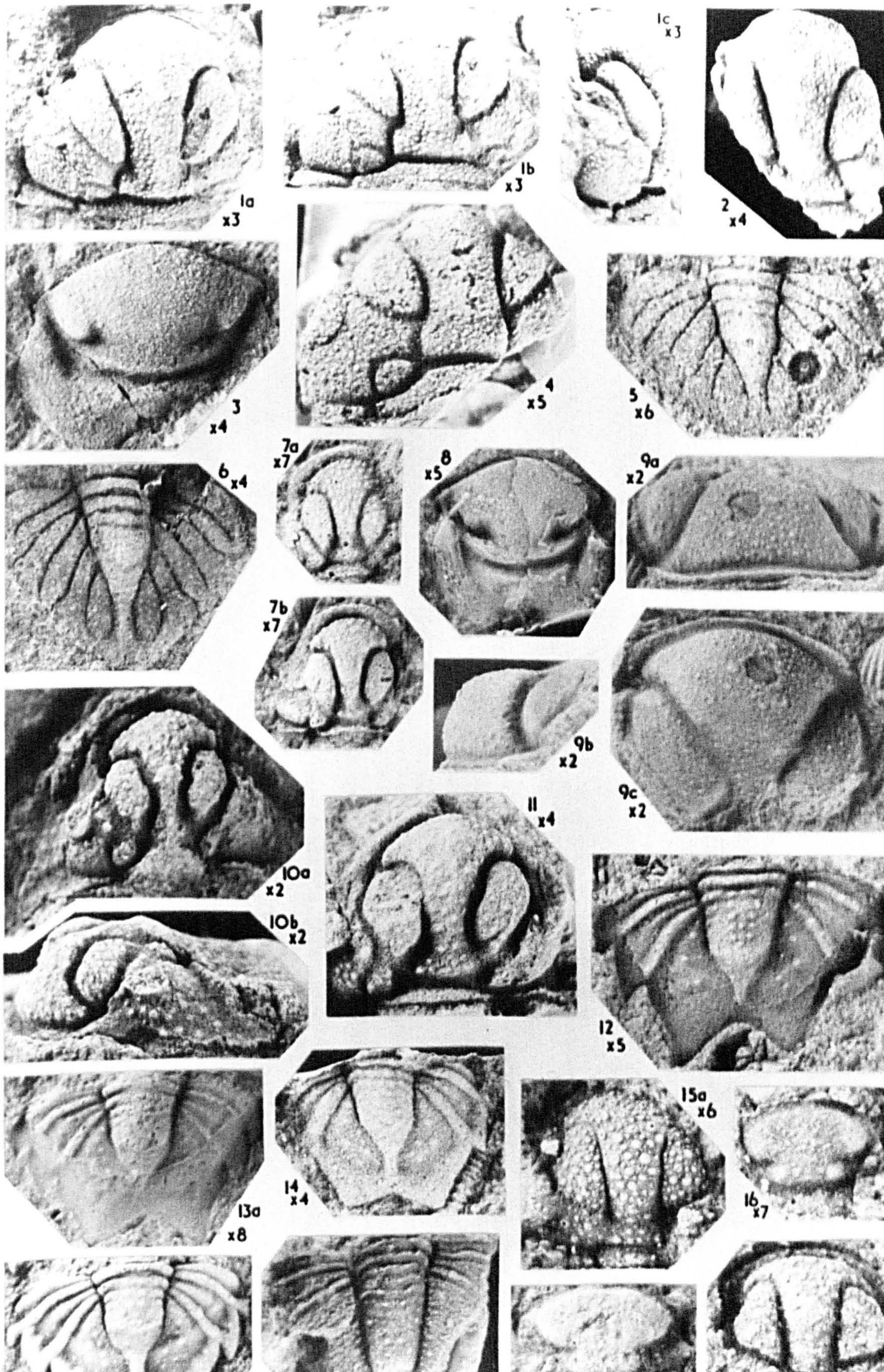
Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

7a,b. Holotype cranidium, dorsal view, 7a latex rubber cast of external mould, 7b internal mould. Figured Reed 1935a, pl.3, fig.11; Tripp 1958, pl.85, fig.18. BM In36953.

10a,b. Cephalon, internal mould, 10a dorsal view, 10b lateral view. BM In37072.

12. Pygidium, internal mould, dorsal view. Figured Reed 1935a, pl.3, fig.9; Tripp 1958, pl.85, fig.19. BM In36955.

PLATE 20



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	Leonaspis cf. *L. deflexa* (Lake, 1896)	147
	Mulloch Hill Formation, Locality 8 (Rough Neuk).	
12.	Latex rubber cast of external mould of pygidium, dorsal view. YH R28.	
	Leonaspis aff. *L. varbolensis* Bruton, 1967	148
	Woodland Formation, Locality 18 (Woodland Point).	
13a,b.	Pygidium, dorsal view, 13a latex rubber cast of external mould, 13b partly exfoliated. Figured Reed 1906, pl.15, fig.14. BM In22825.	
16.	Incomplete pygidium, dorsal view. SM A35115.	
	Leonaspis sp. indet. D	151
	Mulloch Hill Formation, Locality 8 (Rough Neuk).	
14.	Free cheek, internal mould, dorsal view. SM A34857.	
	Leonaspis sp. indet. B	150
	Woodland Formation, Locality 18 (Woodland Point).	
15.	Incomplete cranidium, partly exfoliated, dorsal view. BM In22821.	
	Mulloch Hill Formation, Locality 8 (Rough Neuk).	
17.	Latex rubber cast of external mould of cranidium, dorsal view. YH R19.	
	Mulloch Hill Formation, Locality 6 (Craigens).	
18.	Cranidium, internal mould, dorsal view. HM A3291.	
	Leonaspis sp. indet. E	151
	Woodland Formation, Locality 18 (Woodland Point).	
19.	Thoracic segment, axial ring missing, dorsal view. BM In22827.	

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Fig.		Page
	<u>Hemiarges</u> <u>rolfei</u> Lamont, 1965	143

Knockgardner Formation, Locality 24 (Knockgardner Quarry).

1a,b. Cranidium, internal mould, 1a anterodorsal view, 1b dorsal view. YH 3K5.

2. Latex rubber cast of external mould of part of pygidium, dorsal view. YH 3K14.

3. Part of right pleural field of pygidium, internal mould. YH 4K19.

<u>Hemiarges</u> hypostome Type A — 145

Newlands Formation, Locality 14 (Newlands Farm).

4. Hypostome, internal mould, ventral view. HM A3386.

Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

7. Hypostome, internal mould ventral view. BM In47720.

<u>Hemiarges</u> hypostome Type B — 145

Woodland Formation, Locality 18 (Woodland Point).

5. Hypostome, internal mould, ventral view. YH WA6.

6. Hypostome, ventral view. YH WAA10.

<u>Hemiarges</u> hypostome Type C — 146

Mulloch Hill Formation, Locality 5.

8. Hypostome, internal mould, ventral view. YH KH5/22.

<u>Leonaspis</u> cf. <u>L.</u> <u>deflexa</u> (Lake, 1896) — 147

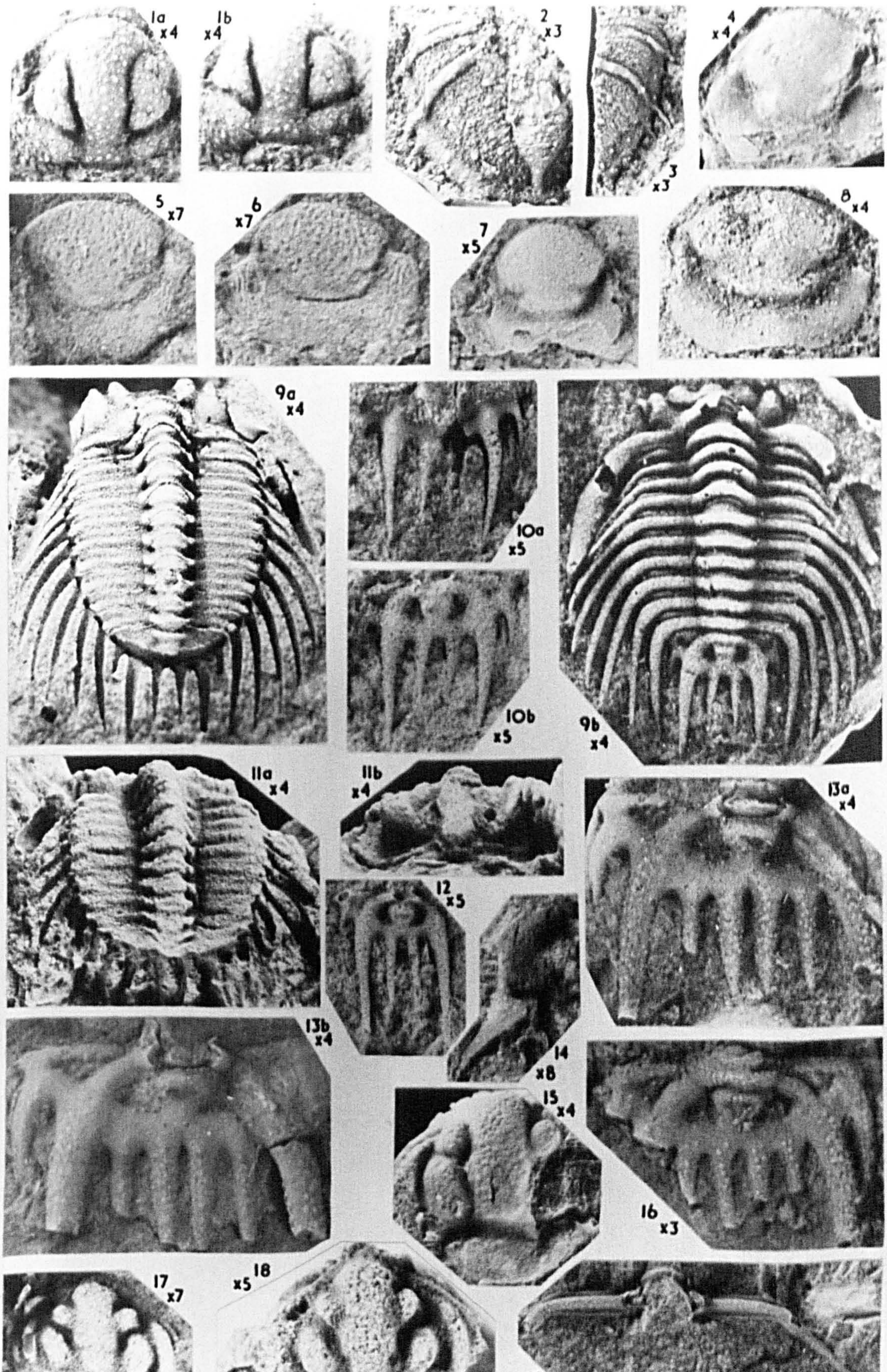
Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

9a,b. Almost complete individual, dorsal view, 9a internal mould, 9b latex rubber cast of external mould. Figured Reed 1906, pl.15, fig.15. BM In22828.

10a,b. Pygidium, dorsal view, 10a internal mould, 10b latex rubber cast of external mould. Figured Nicholson & Etheridge 1878, text-fig.7C. BM In22831.

11a,b. Enrolled individual, internal mould, 11a dorsal view, 11b anterior view of cranidium. BM In22830.

PLATE 21



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	<u>Anacaenaspis</u> <u>callipareos</u> (Thomson, 1857)	158

Woodland Formation, Locality 18 (Woodland Point).

10a-c. 10a incomplete individual, partly exfoliated, dorsal view, 10b latex rubber cast of external mould of part of cephalon and part of thorax, dorsal view, 10c plaster replica of hypostome, ventral view. BM In37030

Newlands Formation, Locality 14 (Newlands Farm).

11. Latex rubber cast of external mould of cephalon, dorsal view. HM A3289.

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	Leonaspis sp. indet. A	150

Woodland Formation, Locality 18 (Woodland Point).

1. Cranidium, partly exfoliated, dorsal view. BM In22819.

Leonaspis sp. indet. C — 151

Newlands Formation, Locality 14 (Newlands Farm).

2. Latex rubber cast of external mould of small cranidium, dorsal view ('S.E.M.' photograph). YH NW118.

Leonaspis _acarescola_ sp. nov. — 153

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

3. Incomplete individual, internal mould, dorsal view. GSE 5776.
4. Latex rubber cast of external mould of almost complete individual, dorsal view. Figured Nicholson & Etheridge 1879, pl.14, fig.14. On same slab as Fig.3.
5. Hypostome, internal mould, dorsal view, originally part of specimen of Fig.4 but removed to excavate specimen. On same slab as Fig.3.

Leonaspis aff. _L._ _angelini_ (Prantl & Přibyl, 1949) — 155

Wood Burn Formation, Locality 21 (Bargany Pond Burn).

6. Latex rubber cast of external mould of thorax and pygidium, dorsal view. GSM YFF9394.
7. Latex rubber cast of external mould of pygidium, dorsal view. YH B13.

Anacaenaspis _callipareos_ (Thomson, 1857) — 158

Mulloch Hill Formation, Locality 9 (Mulloch Hill, in Wood).

8. Cranidium, internal mould, dorsal view. BM In37029.

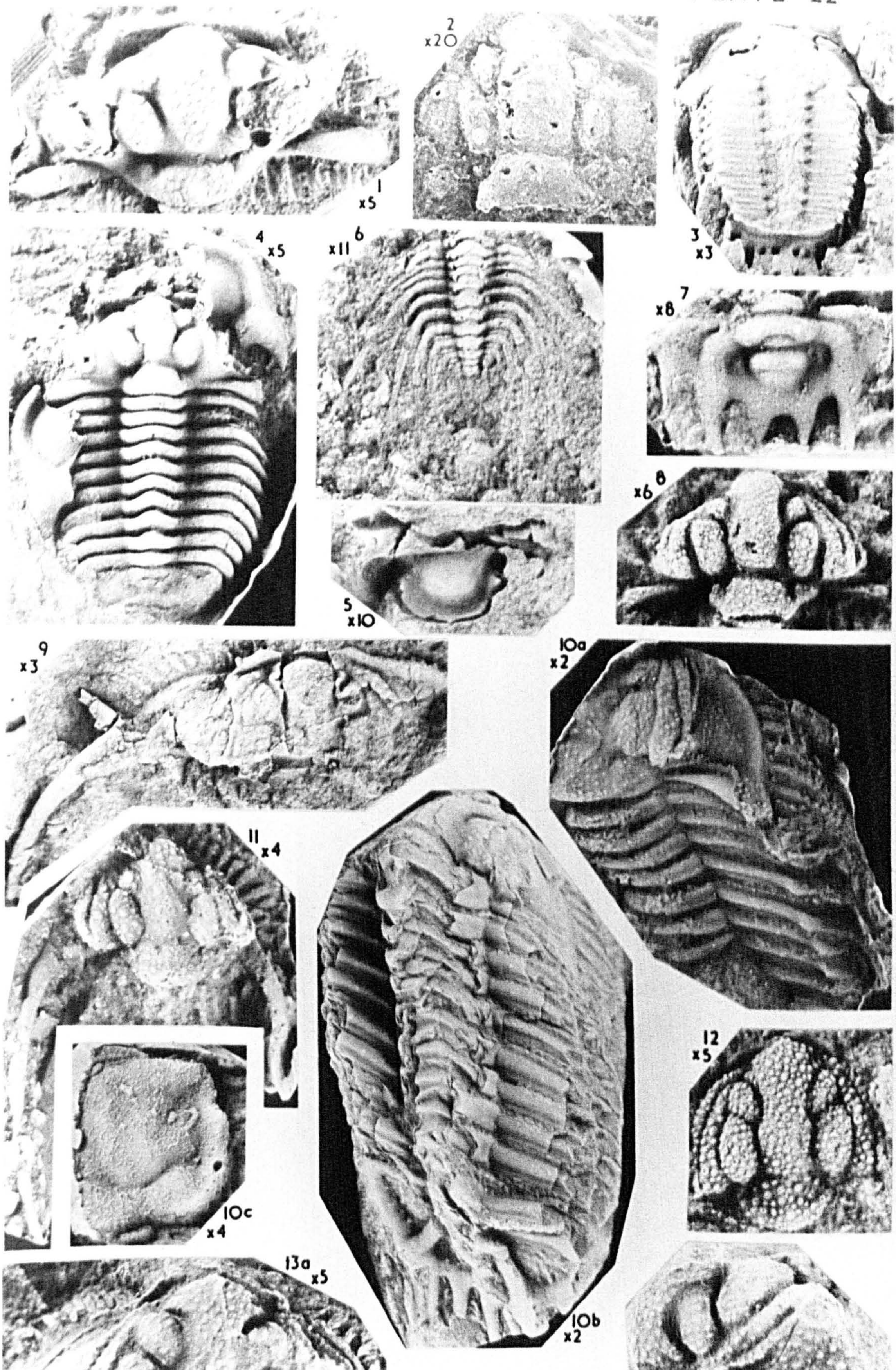
12. Latex rubber cast of external mould of cranidium, dorsal view. Figured Reed 1935, pl.3, fig.22. BM In36956.

13a,b. Incomplete cephalon, internal mould, 13a dorsal view, 13b lateral view showing anterior facial suture. BM In47742.

Woodland Formation, Locality 18 (Woodland Point).

9. Incomplete cephalon, partly exfoliated, dorsal view. Figured Reed 1906, pl.15, fig.12. BM In22817.

PLATE 22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	<u>Ceratocephala</u> sp.	167

Wood Burn Formation, Locality 22 (Penkill).

11. Damaged cephalon, partly exfoliated, dorsal view. Figured Reed 1906, pl.15, fig.11. BM In22816.

	<u>Stenopareia</u> <u>acymata</u> sp. nov.	40

Woodland Formation, Locality 18 (Woodland Point).

12. Cranidium, dorsal view. Figured Nicholson & Etheridge 1879, pl.11, fig.14. HM A137.

PLATE 23

Fig. Page

<u>Anacaenaspis</u> <u>callipareos</u> (Thomson, 1857) 158

Newlands Formation, Locality 14 (Newlands Farm).

1. Latex rubber cast of external mould of free cheek, dorsal view. HM A3290.

Odontopleurinae gen. indet. 165

2. Incomplete pygidium, internal mould, dorsal view. Same locality as Fig.1. HM A3296.

<u>Globulaspis</u> <u>prominens</u> Reed, 1931a 163

Newlands Formation, Locality 14 (Newlands Farm).

3a-c. Cranidium, 3a internal mould, anterodorsal view, 3b latex rubber cast of posterior part of cranidium, dorsal view, 3c internal mould dorsal view. YH NW42.

4. Holotype cranidium, internal mould, dorsal view. Figured Reed 1931a, pl.5, figs.5,5a,b. HM A1066.

6. Latex rubber cast of external mould of cranidium, dorsal view. SM A74590.

<u>Ceratocephalina</u> <u>reperta</u> (Reed, 1925) 168

Newlands Formation, Locality 14 (Newlands Farm).

5. Holotype latex rubber cast of external mould of small cranidium, dorsal view ('S.E.M.' photograph). BM In36957.

8. Cranidium, internal mould, dorsal view. YH N625.

<u>Miraspis</u> <u>ultima</u> Reed, 1931 165

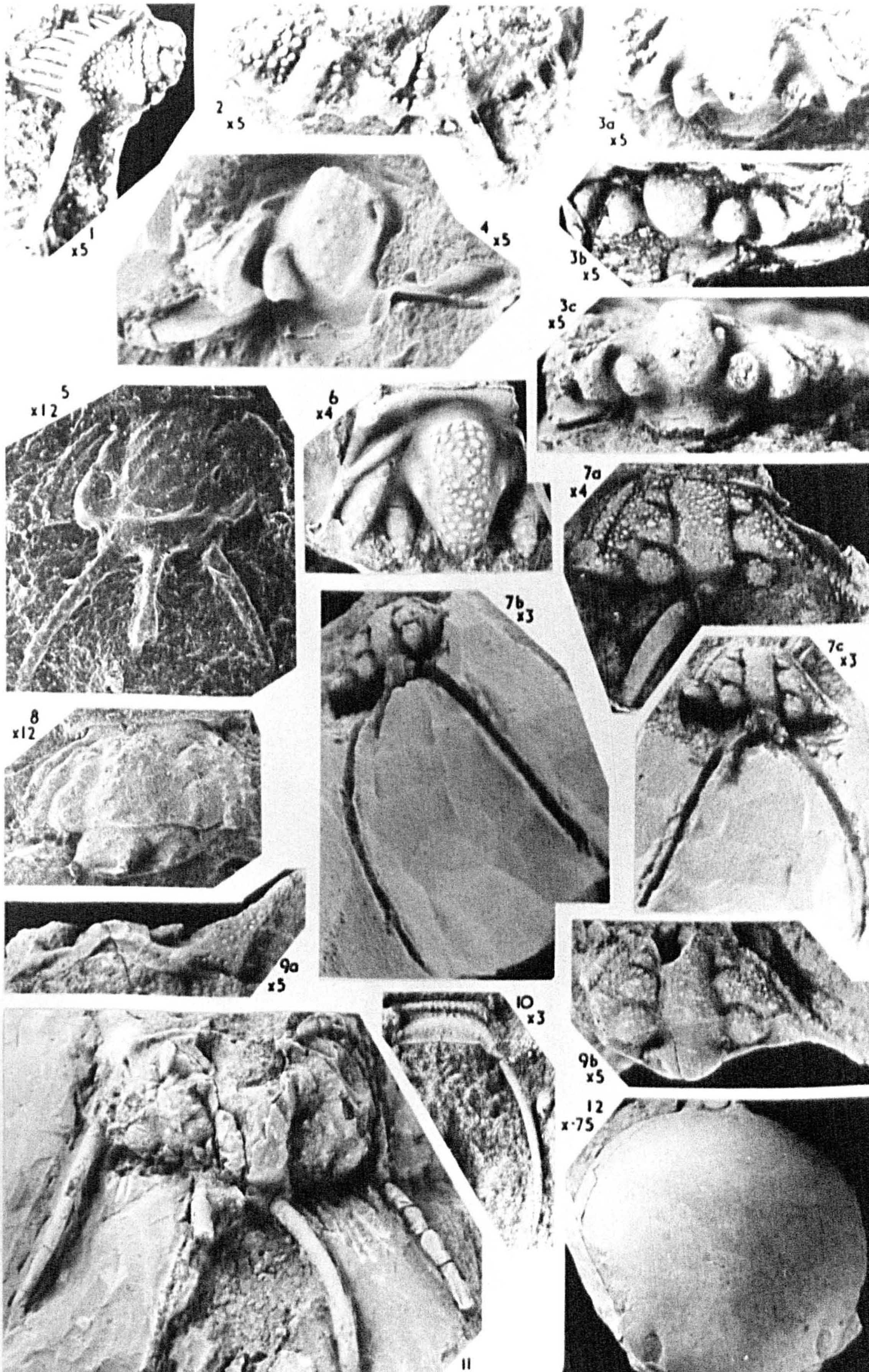
Newlands Formation, Locality 14 (Newlands Farm).

7a-c. Cranidium, 7a latex rubber cast of external mould, dorsal view, 7b internal mould, oblique posterior view, 7c internal mould, dorsal view. BM In22822.

9a,b. Holotype cranidium, internal mould, 9a posterior view showing pedunculate eye, 9b dorsal view. Figured Reed 1931, pl.5, figs. 6,6a. HM A1065.

10. Latex rubber cast of external mould of pleura and spine of thoracic segment, dorsal view. SM A74679.

PLATE 23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